Dissolved Oxygen Water Quality Objective

CEQA Scoping Document
for
Potential Basin Plan Amendment

Prepared by

Staff to
North Coast Regional Water Quality Control Board
Santa Rosa, CA

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Proposed Revision of
the Dissolved Oxygen Water Quality Objective
for the North Coast Region
Scoping Document

Abstract: The Regional Water Quality Control Board (Regional Board) directed staff in its 2007 Triennial Review of the Water Quality Control Plan for the North Coast Region (Basin Plan) to develop a proposal for the revision of the water quality objectives (objective) for dissolved oxygen (DO) as contained in the Basin Plan. This is a Scoping Document designed to initiate the public scoping process under the California Environmental Quality Act (CEQA). It provides an initial assessment of the issues associated with the existing DO objective and Regional Board staff's preliminary proposal for revising the objectives. Following the scoping process, Regional Board staff will draft a Basin Plan Amendment and Staff Report and the Regional Board will consider public comment prior to the Board's decision regarding adoption of the amendment.

The existing DO objectives were put into effect in 1975 and have remained unchanged since that time. The DO objectives are contained in two places within the Basin Plan: 1) page 3-4.00 under the heading "Dissolved Oxygen" and 2) Table 3-1 on pages 3-6.00 through 3-8.00. The objectives on page 3-4.00 are based on the life cycle requirements of sensitive aquatic species and are applicable throughout the region. These objectives are herein after referred to as the *life cycle DO objectives*. The objectives in Table 3-1 are based on background conditions as measured by extensive regional sampling in the 1950s and 1960s and are applicable in individually named waterbodies. These objectives are herein after referred to as *background DO objectives*. At present, the *background DO objectives* take precedence over the *life cycle DO objectives* for those waterbodies named in Table 3-1 of the Basin Plan.

Revision of the DO objectives is necessary because: 1) the *life cycle DO objectives* are given only as daily minimum requirements and thus allow for multiple, consecutive days of marginal conditions; 2) the *background DO objectives* are based on grab sample data which, in some instances, inaccurately depicts actual background conditions; and 3) the listing of threatened and endangered aquatic species in the region and the specter of global warming call for updated and innovative approaches to water quality regulation.

Staff proposes three fundamental changes to the existing DO objectives. First, the framework of the DO objectives should be reversed so that the *life cycle DO objectives* take precedence over the *background DO objectives*. This is to better ensure that threatened and endangered aquatic species receive the immediate protection they require. Second, the *life cycle DO objectives* should be updated to include weekly average limits so as to better prevent the occurrence of multiple days of marginal conditions. Third, in those waterbodies where natural conditions prevent the attainment of *life cycle objectives*, the existing *background DO objectives* should be updated.

Staff proposes that these revisions apply to both warm and cold freshwater habitat within the region, including habitat used for spawning, reproduction, and/or early development. There appears at present no reason to revise the DO objectives designed to protect marine habitat (MAR) and inland saline water habitat (SAL).

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CHAPTER I. INTRODUCTION

This Scoping Document is intended to describe the issues associated with Dissolved Oxygen (DO) in the North Coast Region (Region 1) and the proposal of staff of the North Coast Regional Water Quality Control Board (Regional Board) to revise the existing water quality objective (objective) for DO as it is now contained in the Water Quality Control Plan for the North Coast Region (Basin Plan). It is intended to serve as the basis for the California Environmental Quality Act (CEQA) scoping process in which interested parties are given the opportunity to provide their comments on the issues associated with DO and provide information and recommendations for the revision of the DO objectives.

Following the CEQA scoping process, Regional Board staff will draft a proposed amendment to the Basin Plan and a Staff Report with the technical analysis necessary to support revisions to the DO objectives. The Regional Board will hold a workshop and hearing to provide opportunity to interested parties to comment on the proposed Basin Plan Amendment and supporting documentation prior to the Board's decision regarding adoption of the amendment. Following this, the State Water Resources Control Board (State Board) will hold a hearing in preparation for their decision regarding adoption of the amendment. Finally, the Office of Administrative Law (OAL) will provide a legal review of the amendment before forwarding it to the U.S. Environmental Protection Agency (USEPA) for their approval.

1.1 Background Information on Existing DO Objectives

The Regional Board adopted and the State Board approved the first Basin Plan in 1975. Objectives for DO were included and have remained unchanged since that time. The DO objectives are contained in two places within the Basin Plan: 1) page 3-4.00 under the heading "Dissolved Oxygen" and 2) Table 3-1 on pages 3-6.00 through 3-8.00. (See Appendix A for a copy of these pages).

The DO objectives on page 3-4.00, herein after referred to as the *life cycle DO objectives*, are based on the life cycle requirements of sensitive aquatic species and are applicable in waterbodies throughout the region based on the designated beneficial use(s) of individual waterbodies. There are four separate *life cycle DO objectives* each designed to protect specific beneficial uses: 1) WARM[1], MAR[2], or SAL[3]; 2) COLD[4]; 3) SPWN[5]; and 4) SPWN during critical spawning and egg incubation periods.

[1] WARM stands for Warm Freshwater Habitat and refers to uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

[2] MAR stands for Marine Habitat and refers to uses of water that support marine ecosystems, including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).

[3] SAL stands for Inland Saline Water Habitat and refers to uses of water that support inland saline water ecosystems including, but not limited to, preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates.

[4] COLD stands for Cold Freshwater Habitat and refers to uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

The objectives in Table 3-1 are based on background conditions as measured by extensive regional sampling in the 1950s and 1960s and are applicable in individually named waterbodies. These objectives are herein after referred to as *background DO objectives*. At present, the *background DO objectives* take precedence over the *life cycle DO objectives* for those waterbodies named in Table 3-1 of the Basin Plan.

1.2 Revision of Existing DO Objectives

Revision of the DO objectives is necessary because: 1) the *life cycle DO objectives* are given only as daily minimum requirements and thus allow for multiple, consecutive days of marginal, stressful conditions; 2) the *background DO objectives* are based on grab sample data that in some instances inaccurately depicts background conditions; and 3) the listing of threatened and endangered aquatic species in the region and the specter of global warming call for updated and innovative approaches to water quality regulation.

Staff's preliminary assessment indicates as appropriate three fundamental changes to the existing DO objectives. First, the framework of the DO objectives should be reversed so that the *life cycle DO objectives* take precedence over the *background DO objectives*. In part, staff recommends this change because the data associated with the DO requirements of sensitive aquatic organisms is robust and guidance on the development of ambient aquatic life criteria straightforward. The data used to determine background DO conditions, on the other hand, are outdated and of unknown quality. Such a change will also better ensure that threatened and endangered aquatic species receive the immediate protection they require.

Second, the *life cycle DO objectives* should be updated to include weekly average limits so as to better prevent the occurrence of multiple days of marginal, stressful conditions. The existing daily minimum DO objectives are established to protect against acute effects but allow for some sub chronic effects. When the daily minimum limits are reached now and again, no harm is predicted. However, when they are reached for several days or weeks at a time, sub chronic effects are possible. To prevent against this, USEPA (1986) recommends the development of weekly average limits to accompany daily minimum limits.

Third, in those waterbodies where natural conditions prevent the attainment of *life cycle objectives*, the existing *background DO objectives* should be updated. Modern DO sampling equipment allows for automatic sampling and in-situ analysis at pre-determined increments of time over days and weeks. These data represent DO conditions over a 24-hour period and provide true daily minima, as well as other statistics. In addition, modern sampling equipment allows for the collection of atmospheric pressure, temperature, and salinity data, so that calculating DO saturation is a relatively simple matter. Finally, there are several methods of estimating background stream temperatures based on hydrology, topography, vegetative cover, and other factors.

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[5] SPWN stands for Spawning, Reproduction, and/or Early Development and refers to uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

As such, staff recommends that the existing *background DO objectives* be replaced with a method for individually calculating background DO conditions based on DO saturation derived from an estimate of background *temperature* conditions. Staff further proposes that calculation of background DO conditions only be allowed for use as the DO objective in those waterbodies where natural conditions (e.g., naturally elevated nutrients load/organic matter load or naturally elevated stream temperatures) prevent the attainment of the *life cycle DO objectives*. Finally, to prevent lasting harm in COLD waterbodies, staff recommends a minimum daily limit of 6.0 mg/L be applied.

1.3 Document Format

This Scoping Document is formatted as an annotated outline of the Staff Report: defining the problems, assessing the causes, and proposing a possible solution based on staff's preliminary assessment. The annotated outline will be further fleshed out, following the CEQA scoping process, to produce the draft Staff Report and proposed Basin Plan Amendment. The Scoping Document—and the Staff Report that will follow—includes the following information.

1. An introduction;
2. A general discussion of dissolved oxygen and its interaction and function in the environment;
3. A review of the existing DO objectives;
4. An assessment of the problems associated with the existing DO objectives and preliminary findings;
5. Proposed revisions to the DO objective;
6. A proposed implementation plan designed to result in achievement of the proposed DO objectives, should they be adopted;
7. A proposed monitoring plan designed to confirm achievement of the proposed DO objectives, should they be adopted;
8. Demonstration of compliance with CEQA requirements; and,
9. A list of references.

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CHAPTER II. GENERAL DISCUSSION OF DISSOLVED OXYGEN

Dissolved Oxygen (DO) provides an excellent measure of general aquatic health. It is one of the primary water quality factors that define the habitability of a given aquatic system. Yet, it varies considerably both temporally and spatially in the natural environment. To interpret DO data, one must know something about the factors influencing its concentration and the expected pattern and range of its variation to be able to discern any harmful impacts. A general discussion of these issues follows.

2.1 What is Dissolved Oxygen?

Dissolved oxygen, most often measured in mg/L, is the amount of oxygen gas present in a volume of water. Water has a limited capacity to hold oxygen gas in solution. This capacity is defined by a mathematical relationship among the temperature, atmospheric pressure, and salinity at a given site. When water has reached its capacity to hold oxygen gas in solution it is said to be "saturated."

Dissolved oxygen is added to the water column through diffusion from air[6]; turbulence; and photosynthesis. It is removed from the water column by the respiration of aquatic organisms, the decomposition of organic matter, and other chemical reactions utilizing oxygen. Dissolved oxygen is passively lost from the water to the air as the result of any changes in atmospheric pressure, temperature, and/or salinity which serve to decrease DO saturation.

2.2 Why is dissolved oxygen important?

Oxygen is necessary for the respiration of all aerobic organisms. Because water has a limited capacity to hold oxygen gas in solution, aquatic organisms have evolved specialized structures or methods of extracting from water the limited amount of oxygen that is present in it. These structures or methods generally rely on the partial pressure differential between the oxygen in the water and the oxygen in blood (or the equivalent oxygen receptor). Gills, as an example, are designed to allow the diffusion of oxygen from water across the gill membrane to the arterial system.

A healthy aquatic system is generally one in which the DO concentration is at or approaches full saturation. Under these conditions, aerobic organisms can extract from the water column the oxygen necessary to ensure basic metabolic success (e.g., growth, general health, and reproduction) leading to a greater likelihood of population success. Further, an aquatic system approaching DO saturation is better able to support a wide and diverse array of life forms than one which does not.

As the concentration of DO in water reaches concentrations significantly less than saturation, the oxygen partial pressure gradient between the water column and blood (or equivalent oxygen receptor) is reduced and the ability of the gill structure to acquire the necessary oxygen for respiration is impaired. This can lead to chronic effects, such as

[6] Oxygen accounts for about 21% of the volume of air, but accounts for a considerably smaller proportion of the volume of water. This phenomenon results in an oxygen partial pressure differential tending to cause the diffusion of oxygen from air to water, but limited by the solubility of oxygen in water.

reduced growth, increased susceptibility to disease, or reduced reproductive success. It can also lead to acute effects, such as suffocation and death.

2.3 What are the factors influencing the concentration of dissolved oxygen?
The concentration of DO in an aquatic environment is controlled by the capacity of the water to hold DO (DO saturation) *and* the percent of that capacity which is actually utilized (% DO saturation).

2.3.1 DO saturation
As described above, DO saturation is defined by the mathematical relationship among three variables: atmospheric pressure, temperature, and salinity. The variation in DO saturation is proportional with variation in atmospheric pressure and is inversely proportional with variation in temperature and salinity.

At saturation, oxygen is diffused across the air-water interface until the partial pressure of oxygen in the air is equal to the partial pressure of oxygen in water. At this point of equilibrium, the water is said to be saturated. An increase in atmospheric pressure will naturally increase the differential in oxygen partial pressure between water and air resulting in additional diffusion of oxygen from air to water until equilibrium is once again achieved.

On the other hand, because oxygen molecules are more reactive than water molecules, when a waterbody is heated, the oxygen bubbles contained in water become excited and break the air-water interface at a faster rate than the water molecules vaporize. A pot of boiling water provides an illustration of this phenomenon. The result is a reduction in DO concentration at saturation as water temperature rises.

Finally, one can visualize water as including H_2O molecules and the spaces between them. The spaces between the H_2O molecules allow for various other molecules to be dissolved in water. If the spaces are generally occupied by oxygen, then as other molecules (such as salts) are added, the number of spaces available for oxygen is reduced. Salinity is a measure of salts and is generally used to define the gradient between freshwater, brackish, and saltwater systems. An aquatic system with a high salinity (e.g., the ocean) will naturally have a lower DO concentration at saturation than will a freshwater system with little or no salinity.

If there were no other factors at play, oxygen would diffuse across the air-water interface until partial pressure equilibrium was achieved. Then, the concentration of DO would only fluctuate as atmospheric pressure, temperature, and salinity fluctuated.

2.3.2 Percent Saturation
In the natural environment, however, there are several other factors at play besides the effects of atmospheric pressure, temperature, and salinity. For example, turbulence, photosynthesis, respiration, organic decomposition, and oxygen demanding chemical reactions also effect the concentration of DO in an aquatic system. These factors, however, do not control the capacity of an aquatic system to hold oxygen in solution (DO

saturation). Instead, they affect the percentage of the capacity that is actually utilized (percent saturation).

Turbulence is a physical process that serves to entrain oxygen from the air into the water column. One most often thinks of waterfalls as mechanisms of turbulence; but, any ruffling of the water surface, such as in a riffle, will also entrain oxygen. As a result of turbulence, running water has higher oxygen content than does still water and all other things being equal will have a higher percent saturation, as well.

The photosynthesis of aquatic plants, algae, and cynobacteria also has a profound effect on the oxygen content of water. Photosynthetic organisms use carbon dioxide to convert the energy contained in sunlight into carbohydrates and oxygen. Aquatic photosynthetic organisms release their oxygen (a waste product) to the water column, temporarily increasing the DO concentration of the water. Areas in which the substrate, light, nutrients and temperature favor the growth of aquatic photosynthetic organisms may see large increases in DO during the late afternoon when the effects of several hours of photosynthesis have accumulated. Such areas may be naturally present in an aquatic system (e.g., wetlands; lakes; and slow moving, shallow river reaches) or promoted by anthropogenic activities (e.g., nutrient enrichment, shade removal, reduction in flow, or reduction in water depth through sediment deposition).

The contribution of oxygen to the water column as a result of photosynthesis occurs only during the daylight hours when photosynthesis is active. This source of oxygen is not present during the night when in the absence of sunlight photosynthesis does not occur. The result is a notable cyclical DO pattern where DO is low in the pre-dawn hours, increases slowly during the morning, reaches a peak prior to sunset, and then declines through the night. This is called a diel cycle.

Turbulence and photosynthesis may cause *supersaturation*, a condition in which the DO concentration exceeds DO saturation. This is represented as a percent saturation greater than 100. The excess oxygen associated with supersaturation may be returned to the air as bubbles or otherwise consumed.

The respiration of aquatic organisms requires oxygen for the process of converting carbohydrates into energy for growth and reproduction. It also results in the release of carbon dioxide as a waste product. The oxygen fueling the respiration of aquatic organisms comes from the water column and as described above is extracted using specialized structures or methods (e.g., gills). Unlike photosynthesis, which only occurs during daylight hours, the respiration of aquatic organisms occurs 24 hours per day. Thus, the consumption of oxygen resulting from respiration is relatively continual.

The decomposition of organic matter in the aquatic environment is a complex process involving numerous organisms and chemical reactions. In its simplest form, the consumption of oxygen due to decomposition is really the consumption of oxygen due to the respiration of aerobic bacteria—Biological Oxygen Demand (BOD). Aerobic bacteria use organic matter as their food source and convert it into carbon dioxide and energy while using oxygen.

In addition to BOD, nitrogen oxygen demand (NOD) in natural waters also affects DO conditions. NOD is considered to be a second stage of the oxygen consuming process that is initiated somewhat later than BOD (carbonaceous dissolved oxygen demand). NOD is also known as nitrification, which is a two-stage process that converts ammonia ($NH4+$) to nitrite ($NO2-$) in the first step and then converts nitrite to nitrate ($NO3-$) in the second step. Both steps of the process involve bacteria to drive the oxidation reactions and both steps consume oxygen. In natural waters NOD usually exerts less oxygen demand than BOD and is contingent on the level of ammonia ($NH4+$) present in the system.

Respiration, decomposition, and oxygen demanding chemical reactions may cause *subsaturation*, a condition in which the DO concentration is reduced below DO saturation. This is represented by a percent saturation less than 100. Equilibrium is returned to the system either by sufficient increases in DO (e.g., day time photosynthesis, turbulence associated with winter rains, mechanical mixing, etc.), reduction in oxygen-demanding compounds (e.g., reduction in fertilizers, slash, erosional products, etc. or increase in the sequestration of nutrients and/or organic matter in wetlands, riparian vegetation, or floodplains) or a loss of respiring organisms (e.g., migration to refugia or a die-off).

CHAPTER III.
EXISTING WATER QUALITY OBJECTIVE FOR DISSOLVED OXYGEN

The Regional Board adopted and the State Board approved the first Basin Plan in 1975. Objectives for DO were adopted and have remained unchanged since that time. The DO objectives are contained in two places within the Basin Plan: 1) page 3-4.00 under the heading "Dissolved Oxygen" and 2) Table 3-1 on pages 3-6.00 through 3-8.00. (See Appendix A for a copy of these pages). The purpose of this chapter is to describe the DO objectives as they currently exist. An assessment of their current applicability and recommended revisions are given in Chapter IV.

3.1 Life Cycle DO Objectives

The DO objectives on page 3-4.00 of the Basin Plan (see Appendix A), herein after referred to as the *life cycle DO objectives*, are based on the life cycle requirements of sensitive aquatic species and are applicable in waterbodies throughout the region based on the designated beneficial use(s) of individual waterbodies. The Porter-Cologne Water Quality Control Act, (Cal. Water Code, Division 7), Section 13050(f), defines beneficial uses as follows:

> "Beneficial uses" of the waters of the state that may be protected against quality degradation include, but are not limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves.

DO objectives are developed for the protection of five beneficial uses related to the preservation and enhancement of fish: marine habitat (MAR), inland saline water habitat (SAL), warm freshwater habitat (WARM), cold freshwater habitat (COLD), and spawning, reproduction, and/or early development (SPWN).

Table 2-1 of the Basin Plan (see Appendix A for a copy of these pages) lists all of the waterbodies in the North Coast region and their beneficial uses. There are 132 separate waterbodies listed in Table 2-1. Of these, 13% (17) are designated as existing or potentially existing MAR, 2% (2) as existing or potentially existing SAL, 49% (64) as existing or potentially existing WARM, 98% (129) as existing or potentially existing COLD, and 95% (125) as existing or potentially existing SPWN.

The Basin Plan establishes ambient water quality objectives for DO, as follows.

- ✓ 5.0 mg/L DO as a daily minimum for the protection of MAR, SAL, and WARM.
- ✓ 6.0 mg/L DO as a daily minimum for the protection of COLD.
- ✓ 9.0 mg/L DO as a daily minimum for the protection of SPWN during critical spawning and egg incubation periods and 7.0 mg/L DO as a daily minimum for the protection of SPWN during the rest of the year.

Beneficial uses are designated by hydrologic unit, hydrologic area, hydrologic subarea, and in a few cases, by specific waterbody. They are not designated by reach. Further, as described on page 2-1.00 of the Basin Plan, “the beneficial uses of any specifically identified water body generally apply to all its tributaries.” This is sometimes referred to as the Tributary Rule. Based on the Tributary Rule, a watercourse not specifically named in Table 2-1 of the Basin Plan is generally designated the same beneficial uses as that of the downstream watercourse into which it flows.

With respect to DO, most of the waterbodies designated as MAR, SAL or WARM are also designated as COLD. As such, the COLD DO objective (6.0 mg/L as a daily minimum) generally applies to these waterbodies. Further, most of the waterbodies designated as COLD are also designated as SPWN. As such, the SPWN DO objective (7.0 mg/L as a daily minimum) generally applies to these waterbodies, except during critical periods of spawning and egg incubation. During critical periods of spawning and egg incubation a SPWN DO objective of 9.0 mg/L as a daily minimum applies. At present, the *life cycle DO objectives* are only applied in waters not listed in Table 3-1 and in waters in Table 3-1 for which no DO objectives are assigned.

3.2 Background DO Objectives

The objectives in Table 3-1 of the Basin Plan (see Appendix A) are based on background conditions as measured by extensive regional sampling in the 1950s and 1960s and are applicable in individually named waterbodies. These objectives are herein after referred to as *background DO objectives* and take precedence over the *life cycle DO objectives* in those waters listed in Table 3-1. For waterbodies from the Stemple Creek north up to but not including the Klamath River, the *background DO objective* assigned in Table 3-1 is 7.0 mg/L as a daily minimum, except in Humboldt and Bodega bays which are assigned a *background DO objective* of 6.0 mg/L as a daily minimum. For waterbodies from the Klamath River up to the Oregon border, the *background DO objectives* range depending on the waterbody from 5.0 mg/L as a daily minimum to 9.0 mg/L as a daily minimum.

The data used to establish background conditions were collected by a range of partners including federal, state and local agencies. The Department of Water Resources published the data in annual bulletins beginning with data from 1951. Generally, the data are monthly grab samples that were collected during day light hours and analyzed in the field using a modified Winkler method (see Chapter IV below). Data are reported both as concentrations [parts per million (ppm) which is equivalent to mg/L] and as percent saturations. From these data, the Regional Board adopted site-specific objectives.

In addition to daily minimum *background DO objectives*; the Regional Board also adopted annual 50 percentile and 90 percentile objectives for some waterbodies. Compliance with these objectives is based on a calculation of the monthly means over the course of 12 months.

The Basin Plan prohibits the point source discharges of waste to waterbodies in the North Coast Region, except in the Mad, Eel, and Russian Rivers during the rainy season (Oct. 1 to May 14). The extensive and regular water quality monitoring that was the hallmark of an earlier era in water quality regulation, occurs today in the North Coast region only sporadically. As a practical matter, then, data sufficient to determine compliance with annual objectives generally only exists where point source discharges have been permitted and then only for the period of discharge. As such, the annual objectives are rarely applied.

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CHAPTER IV.
ASSESSMENT OF EXISTING DO OBJECTIVES AND RECOMMENDATIONS

Regional Board staff has conducted a preliminary assessment of the existing DO objectives, the results of which are presented below. Staff has conducted this assessment for several reasons. 1) An earlier staff assessment of temperature objectives resulted in a preliminary draft staff report (Zabinsky and Azevedo 2005) in which revisions to both the temperature and DO objectives were recommended. 2) Modeling conducted on the Klamath River in support of the TMDL for DO (and other parameters) indicates that the *background DO objective* for the Klamath River is inaccurate and unattainable. A TMDL for DO can not be adopted until this matter is resolved. 3) The Regional Board approved in 2007 staff's triennial review of water quality priorities in which revision of DO objectives ranked seventh and a proposal to the Board for Basin Plan amendment was scheduled for 2009. 4) One key inspiration of these efforts is concern over the status and continued existence of threatened and endangered cold water species in the North Coast region, specifically salmonids. This concern is magnified by the specter of global warming and its effects on temperature-related parameters such as DO.

The preliminary assessment is composed of three parts:

A. A comparison of the *life cycle DO objectives* to USEPA guidance on ambient aquatic life requirements and other relevant scientific literature;
B. In light of the issues that have arisen in the Klamath River TMDL, an assessment of the general accuracy of the *background DO objectives*;
C. An assessment of the general framework of the existing DO objectives, with a specific look towards ensuring protection of threatened and endangered aquatic species and considering the effects of global warming.

4.1 Assessment of *Life Cycle DO Objectives*

Since the adoption of the original Basin Plan in 1975, the U.S. Environmental Protection Agency (USEPA) has updated its guidance for establishing ambient water quality criteria in freshwater systems (USEPA 1986), otherwise known as the Gold Book. This is the prevailing guidance available for the development of water quality objectives for DO. In 2005, Regional Board staff (Carter 2005) performed a review of the scientific literature associated with the DO requirements of salmonids and determined that the recommendations contained in USEPA (1986) comport well with the findings of scientific studies performed since that time. In this section, Regional Board staff compares the *life cycle DO objectives* contained in the Basin Plan[7] to USEPA guidance so as to identify areas of the Basin Plan potentially requiring revision. Staff also makes preliminary recommendations.

4.1.1 Overview of USEPA Guidance

USEPA (1986) correlates aquatic production impairment to DO concentration for salmonid waters, nonsalmonid waters, invertebrates, and for various life cycle stages.

[7] The *life cycle DO objectives* in the Basin Plan include daily minimum values designed to protect: MAR, SAL, WARM, COLD, and SPWN.

This is compiled in Table 2 of the document. USEPA (1986) analyzes a wide body of scientific literature to identify the DO concentrations appropriate for providing:

- ✓ No production impairment,
- ✓ Slight production impairment,
- ✓ Moderate production impairment,
- ✓ Severe production impairment, and a
- ✓ Limit to avoid acute mortality.

The following are excerpts of USEPA's (1986) recommendations as they relate to the development of water quality objectives for DO in the North Coast Region. A copy of Table 2 from this guidance can be found in Appendix B.

1. "Criteria for early life stages are intended to apply only where and when these stages occur."

2. "If slight production impairment or a small but undefinable risk of moderate impairment is unacceptable, than one should use the 'no production impairment' values given in the document as means and the 'slight production impairment' values as minima."

3. "Once a series of daily mean dissolved oxygen concentrations are calculated, an average of these daily means can be calculated. For embryonic, larval and early life stages, the averaging period should not exceed 7 days…Other life stages can probably be adequately protected by 30-day averages. Regardless of the averaging period, the average should be considered a moving average rather than a calendar-week or calendar-month average."

4. "During periodic cycles of dissolved oxygen concentrations, minima lower than acceptable constant exposure levels are tolerable so long as: a) the average concentration attained meets or exceeds the criterion; b) the average dissolved oxygen concentration is calculated as recommended…; and, c) the minima are not unduly stressful and clearly are not lethal."

5. "The significance of conditions which fail to meet the recommended dissolved oxygen criteria depend largely upon five factors: a) the duration of the event; b) the magnitude of the dissolved oxygen depression; c) the frequency of recurrence; d) the proportional area of the site failing to meet the criteria, and e) the biological significance of the site where the event occurs. Evaluation of an event's significance must be largely case- and site-specific."

USEPA has also published ambient water quality criteria for DO in the saltwater systems of the Atlantic coast (USEPA 2000). The published criteria are intended for the Virginian Province (Cape Cod to Cape Hatteras) only. But USEPA (2000) suggests that these criteria might be used elsewhere with proper adjustment. The criteria are presented for:

1. Juvenile and adult survival, a limit for continuous exposure and a limit based on the hourly duration of exposure,
2. Growth effects, a limit for continuous exposure and a limit based on the intensity and hourly duration of exposure, and,
3. Larval requirement effects, a limit based on the number of days a continuous exposure can occur and a limit based on the number of days an intensity and hourly duration pattern of exposure can occur.

4.1.2 Comparison of Life Cycle DO Objectives to USEPA Guidance

As part of its preliminary assessment, Regional Board staff has compared the *life cycle DO objectives* described in Chapter III to USEPA guidance for the development of DO criteria. The preliminary assessment is divided by beneficial use(s): 1) MAR and SAL, 2) WARM, 3) COLD, 4) SPWN, and 5) migration (MIGR) and estuarine habitat (EST), as follows.

4.1.2.1 MAR and SAL

The Basin Plan currently assigns a daily minima DO concentration of 5.0 mg/L as the *life cycle DO objective* for the protection of MAR and SAL. This is implemented as an instantaneous minimum. USEPA does not have specific criteria recommendations for Pacific Coast saltwater environments. But, USEPA (2000) recommends criteria for the saltwater environments of the Atlantic Coast which are useful for a preliminary comparison. USEPA (2000) recommends 2.3 mg/L DO as the criterion minimum concentration (CMC) to ensure juvenile and adult survival. This is applied as a 1-hour average. It also recommends 4.8 mg/L DO as the criterion continuous concentration (CCC) to ensure no negative effects on growth. This is applied as a 4-day average. USEPA's (2000) remaining recommended criteria fluctuate as a function of exposure and duration and thus are not immediately comparable to the Basin Plan's fixed criteria.

Comparing the Basin Plan's *life cycle DO objective* for MAR and SAL to USEPA's recommendations for the Atlantic Coast suggests that 5.0 mg/L DO as a daily minimum is adequate to protect against both chronic and acute effects to saltwater species. An unforeseen complication, however, is that the waterbodies designated in the Basin Plan as MAR (e.g., the estuaries of major North Coast rivers, bays, and harbors) are also designated as COLD[8] and SPWN[9]. As currently written, the DO objective for SPWN generally applies to these waters. Similarly, the Russian Gulch Hydrologic Area and saline wetlands[10] are designated as SAL, as well as COLD and SPWN. As currently written, the DO objective for SPWN generally applies to these waters, too. The pertinent question, then, is whether or not it is appropriate to apply SPWN DO objectives of 7.0 mg/L and 9.0 mg/L to saline waters when DO concentrations at saturation may be considerably less.

[8] Ocean waters are designated as MAR and SPWN, but not COLD.
[9] Crescent City Harbor is designated as MAR and COLD, but not SPWN.
[10] Saline wetlands are designated as existing wetland habitat (WET). All other designated beneficial uses (e.g., COLD, SAL, MAR, and SPWN) are designated as "potentially existing."

Staff's preliminary recommendations:

1. Retain 5.0 mg/L DO as a daily minimum as the *life cycle DO objective* for MAR and SAL to protect against acute and chronic effects on salt water species.
2. Add a phrase clarifying that the *life cycle DO objective* for SPWN is designed to protect freshwater ecosystems. It is not intended to apply in saline environments.
3. Specifically solicit pubic input on the question of whether or not a DO objective designed to protect spawning and early life stages in saline environments is necessary. Request data and other information with which such an objective could be developed, if necessary.

4.1.2.2 <u>WARM</u>

The Basin Plan currently assigns a daily minima DO concentration of 5.0 mg/L as the *life cycle DO objective* for the protection of WARM. This is implemented as an instantaneous minimum. USEPA (1986) recommends as national criteria, 5.0 mg/L DO as a daily minimum and 6.0 mg/L as a 7-day mean for the protection of the early life stages of warm water species. Further, as a national criteria, USEPA (1986) recommends 3.0 mg/L as a daily minimum, 4.0 as a 7-day mean minimum, and 5.5 mg/L as a 30-day mean for the protection of other life stages of warm water species.

Comparing the Basin Plan's *life cycle DO objective* for WARM to USEPA's (1986) national criteria for warm water species, it appears that 5.0 mg/L adequately protects against acute effects to early life stages and acute and chronic effects in other life stages of warm water species. It does not adequately protect, however, against chronic effects in early life stages. A DO objective of 6.0 mg/L applied as a 7-day mean is necessary for this purpose. The 7-day mean should be calculated as a moving mean of daily averages.

As with MAR and SAL, an unforeseen complication is that waterbodies designated as WARM are also designated as COLD and SPWN[11]. As currently written, then, the DO objectives for SPWN generally apply to WARM waters. A pertinent question is whether or not it is appropriate to apply SPWN DO objectives of 7.0 mg/L and 9.0 mg/L to WARM waters when the DO concentration at saturation may be considerably less.

Staff's preliminary recommendations:

1. Retain 5.0 mg/L DO applied as a daily minimum as the *life cycle DO objective* for WARM to protect against acute and chronic effects on juvenile and adult warm water species and acute effects on early life stages of warm water species.
2. Consider adding 6.0 mg/L applied as a 7-day moving average as the *life cycle DO objective* for SPWN to protect against chronic effects in early life stages of warm water species. The 7-day moving average should be calculated using seven consecutive daily means. Daily means should be calculated based on at least the minimum and maximum daily DO values; but, preferably based on data collected less than or equal to every hour over a 24 hour day.
3. Consider adding a phrase that the *life cycle DO objective* for SPWN to protect against chronic effects on early life stages of warm water species only applies

[11] Lakes and reservoirs are generally designated as WARM and COLD, but not SPWN.

where and when the spawning, egg incubation, or larval development of warm water species is present or was historically present.

4.1.2.3 COLD

The Basin Plan currently assigns a daily minima DO concentration of 6.0 mg/L as the *life cycle DO objective* for the protection of COLD. This is implemented as an instantaneous minimum. USEPA (1986) recommends national criteria[12] for the protection of salmonids[13]. But, it also recommends the development of local criteria where "slight production impairment or a small but undefinable risk of moderate impairment is unacceptable (USEPA 1986)." Regional Board staff concludes that slight or moderate impairment is unacceptable in North Coast waterbodies where salmonids are or have historically been present. This is because of the listing of several species of salmonids as threatened or endangered.

Following the guidance for developing local criteria, then, USEPA (1986) recommends a daily minimum DO concentration set at the "slight production impairment" value. Table 2 of USEPA (1986) (see Appendix B) gives this value as 6.0 mg/L for juvenile and adult life stages of salmonids; and, this compares exactly to the daily minimum DO objective contained in the Basin Plan for the protection of COLD.

Because the daily minimum objective is set to allow "slight production impairment," added protection is necessary to ensure that DO concentrations do not remain suppressed at 6.0 mg/L for an extended period of time and result in discernable impairment. Thus, USEPA (1986) further recommends a 7- or 30-day average DO concentration set at the "no production impairment" value. Table 2 of USEPA (1986) (see Appendix B) gives this value as 8.0 mg/L for juvenile and adult life stages of salmonids. The Basin Plan does not currently include any such 7- or 30-day average DO objective.

Staff's preliminary recommendations:

1. Retain 6.0 mg/L DO applied as a daily minimum as the *life cycle DO objective* for COLD to protect against acute effects on juvenile and adult cold water species.
2. Add 8.0 mg/L as a 7-day moving average as the *life cycle DO objective* for COLD to protect against chronic effects on juvenile and adult cold water species. The 7-day moving average should be calculated using seven consecutive daily means. Daily means should be calculated based on at least the minimum and maximum daily DO values; but, preferably based on data collected at intervals less than or equal to every hour over the course of a 24 hour day. Staff recommends a 7-day moving average as better than a 30-day moving average for the protection of salmonids because it is more protective.
3. Add a phrase that acknowledges that COLD objectives are specifically designed to protect salmonids; but extend to other less sensitive cold water organisms, as well.

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[12] USEPA recommends as national criteria for juvenile and adult salmonids, 4.0 mg/L DO as a daily minimum, 5.0 mg/L DO as a 7-day mean minimum, and 6.5 mg/L DO as a 30-day mean.

[13] Cold water objectives are developed based on salmonid life cycle requirements because they are the most sensitive, well-studied organism in cold water systems.

4.1.2.4 SPWN

The Basin Plan currently assigns a daily minimum DO concentration of 9.0 mg/L as the *life cycle DO objective* for the protection of SPWN during critical spawning and egg incubation periods. It assigns a daily minimum DO concentration of 7.0 mg/L as the *life cycle DO objective* for the protection of SPWN during the rest of the year. USEPA (1986) recommends national criteria[14] for the protection of cold water species. But, it also recommends the development of local criteria where "slight production impairment or a small but undefinable risk of moderate impairment is unacceptable (USEPA 1986)." Regional Board staff concludes that slight or moderate impairment is unacceptable in North Coast waterbodies where salmonids are or have historically been present. This is because of the listing of several species of salmonids as threatened or endangered.

Following the guidance for developing local criteria, then, USEPA (1986) recommends a daily minimum DO concentration set at the "slight production impairment" value. Table 2 of USEPA (1986) (see Appendix B) gives this value as 6.0 mg/L as measured in the gravel. USEPA (1986) calculates that 9.0 mg/L DO is necessary in the water column to ensure the attainment of 6.0 mg/L DO in the gravel where embryo and larval development takes place (i.e., converted by adding 3 mg/L). The 9.0 mg/L DO in the water column compares exactly to the existing Basin Plan DO objective for the protection of SPWN during critical spawning and egg incubation periods.

The Basin Plan only requires that ambient water quality conditions for DO be a minimum of 9.0 mg/L during the period of "critical spawning and egg incubation." This compares nicely to USEPA's (1986) admonishment that early life stage criteria only be applied *when* it occurs. Except, the term "early life stages" is defined in USEPA (1986) to include both embryo and larval stages, these being the stages that reside in the gravel. The 9.0 mg/L *life cycle DO objective* for SPWN in the Basin Plan, however, is designed to apply through egg incubation only; it does not extend through the yolk-sac fry stage (i.e., alevins). As currently written, the Basin Plan requires 7.0 mg/L DO in spawning streams during the time that alevins reside in the gravel, before they emerge in the water column as free-swimming fry. Further, the 7.0 mg/L DO objective applies in spawning streams even during periods of the year when there is no spawning, egg incubation or larval development. This is clearly contrary to USEPA's (1986) recommendation.

USEPA (1986) further recommends that early life stage criteria only be applied *where* it occurs. An unforeseen complication in the Basin Plan is that it requires that the *life cycle DO objective* for SPWN be applied throughout whole waterbodies designated as SPWN, even in those reaches that have never been suitable for spawning. Further, the Tributary Rule extends the beneficial uses of identified waterbodies to the unidentified tributaries that drain into them. Yet, in many instances, tributaries to spawning streams are unsuitable themselves for spawning and have never supported said beneficial use.

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[14] USEPA recommends as national criteria for early life stages of salmonids, 8.0 mg/L DO as a daily minimum and 9.5mg/L DO as a 7-day mean.

Finally, because the daily minimum objective is set to allow “slight production impairment,” added protection is necessary to ensure that DO concentrations do not remain suppressed at 9.0 mg/L for an extended period of time and result in discernable impairment. Thus, for early salmonid life stages, USEPA (1986) further recommends a 7-day average DO concentration set at the “no production impairment” value. Table 2 of USEPA (1986) (see Appendix B) gives this value as 11.0 mg/L in the water column. The Basin Plan does not currently include any such 7-day average DO objective.

Staff’s preliminary recommendations:

1. Retain 9.0 mg/L DO applied as a daily minimum as the *life cycle DO objective* for “SPWN during critical spawning and egg incubation periods” to protect against acute effects on early life stages of cold water species. Rename this objective “SPWN.” Clarify that this objective is designed to protect fresh cold water species, only. It is not intended to apply to saline or warm water ecosystems. Add a phrase that SPWN is to be applied in current and historic salmonid spawning habitat when spawning is or has historically occurred. Reference historic records, maps, and/or data produced by the National Marine Fisheries Service, U.S. Fish and Wildlife Service and California Department of Fish and Game for the purpose of determining where and when in individual waterbodies spawning is occurring or has historically occurred. Clarify that where such information is lacking, the SPWN DO objective applies throughout SPWN-designated waterbodies and during the period in which spawning, egg incubation, and larval development occurs or has historically occurred. Identify a calendar period which brackets the existing and historic early life stages of North Coast salmonid species.
2. Add 11.0 mg/L applied as a 7-day moving average as the *life cycle DO objective* for SPWN to protect against chronic effects on early life stages of cold water species. The 7-day moving average should be calculated using seven consecutive daily means. Daily means should be calculated based on at least the minimum and maximum daily DO values; but, preferably based on data collected at intervals less than or equal to every hour over the course of a 24 hour day. Extend the period of time in which $\text{SPWN}_{\text{applies}}$ to include not only spawning and egg incubation, but larval development, as well.
3. Eliminate the 7.0 mg/L daily minimum SPWN DO objective as redundant, unnecessary, and underprotective during larval stages.

4.1.2.5 <u>MIGR and EST</u>

The Basin Plan does not currently include a *life cycle DO objective* for the protection of migrating aquatic organisms (MIGR) or estuarine habitat (EST) where salmonids undergo smoltification prior to their outmigration to the ocean. Further, USEPA (1986) does not address the DO requirements of these life cycle stages directly.

With respect to upstream migration, Carter (2005) cites Hallock et al. (1970) as demonstrating that Chinook wait to migrate until dissolved oxygen levels are at 5 mg/L or higher. Reiser and Bjornn (1979) meticulously compiled data regarding the habitat requirements of salmonids. They report the DO requirements of upstream migrating adults at 80% saturation, with temporary levels no lower than 5.0 mg/L. With this information as the basis for comparison, the existing and proposed *life cycle DO objectives* for COLD appear to adequately protect MIGR, as well.

With respect to downstream migration and estuarine DO conditions a preliminary literature search results in no specific information.

Staff's preliminary proposals:

1. Do not add a *life cycle DO objective* for MIGR. Rely instead on the DO objectives for COLD to provide adequate protection for MIGR, as well.
2. Specifically solicit pubic input on the question of whether or not a DO objective designed to protect the estuarine needs of smolts is necessary. Request data and other information with which such an objective could be developed.

4.2 Assessment of *Background DO Objectives*

In addition to the *life cycle DO objectives*, as described above, the Basin Plan includes in Table 3-1 (see Appendix A) site specific objectives for individually named waterbodies. These DO objectives are designed to take precedence over the *life cycle DO objectives* for those waterbodies identified in Table 3-1 and for which numeric criteria have been identified.

In developing a DO Total Maximum Daily Load for the mainstem Klamath River, Regional Water Board staff determined that the *background DO objectives* for the Klamath River contained in Table 3-1 of the Basin Plan are not attainable, even under natural conditions. This was demonstrated when a series of water quality simulations designed to predict Klamath River mainstem water quality under natural conditions yielded DO concentrations below the *background DO objectives*. The implication of these model results is that a TMDL can not be developed that demonstrates compliance with the current site-specific DO objectives for the Klamath River mainstem.

Regional Water Board staff originally considered proposing a new site-specific DO objective for the Klamath River so that the TMDL could proceed on schedule. But other factors, as described in Section IV above, indicated the need to assess the DO objectives throughout the Region and consider more wide-ranging revisions. What follows is a preliminary assessment of the *background DO objectives* as currently contained in the Basin Plan.

4.2.1 Overview of Background DO Objectives

The Basin Plan was originally written as two plans: one for the Klamath River Basin[15] known as Basin 1A and one for the North Coastal Basin[16] known as Basin 1B. The Basin Plan that was approved by the State Board in 1975 was in actuality two separate

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[15] The Klamath River Basin, or Basin 1A, was defined as all waterbodies draining to the Pacific Ocean from the Oregon border south to and including the Klamath River and Trinity River watersheds.

[16] The North Coastal Basin, or Basin 1B, was defined as all waterbodies draining to the Pacific Ocean from but not including the Klamath River south to Stemple Creek.

plans, one for each basin. It wasn't until 1988 that Basin Plan 1A and Basin Plan 1B were merged into one.

Each of the original Basin Plans was drafted by a different consultant to the State which resulted in slight differences between the two Basin Plans. Table 3-1 of the existing Basin Plan still shows some of those differences.

Table 3-1 is entitled "Specific Water Quality Objectives for North Coast Region" and includes objectives for: specific conductance, total dissolved solids, dissolved oxygen, hydrogen ion (pH), hardness, and boron. Waterbodies from each of the Hydrologic Units[17] are included in Table 3-1. With respect to DO, Table 3-1 objectives apply instead of the *life cycle DO objectives* for those waterbodies included in the Table and for which site-specific DO objectives are given.

4.2.1.1 <u>Klamath Basin (1A)</u>
In the Klamath Basin (1A), the consultant assessed the available data for each Hydrologic Area and proposed a site-specific objective tailored to that Hydrologic Area. For example, the Lower Lost River was assigned a minimum DO objective of 5.0 mg/L while the Shasta River was assigned a minimum DO objective of 7.0 mg/L and the Salmon River was assigned a minimum DO objective of 9.0 mg/L.

All of the waterbodies of the Klamath Basin (1A), except those of the Middle Trinity Hydrologic Area, are listed in Table 3-1, including all the tributaries. As such, for Basin 1A waters, the Table 3-1 DO objectives--given as year round, daily minima--are always applied. Conversely, the *life cycle DO objectives* are never applied to waterbodies in the Klamath Basin 1(A)[18]. As an example, in the Scott and Shasta Rivers, 7.0 mg/L DO is applied as the ambient water quality objective throughout the year, even during those times of the year when early salmonid life stages are present and may require 9.0 mg/L DO as a daily minimum for full protection. Further, it appears that during the spawning season, background conditions (as measured by DWR and its partners) within Basin 1A generally achieved DO concentrations greater than required by the *background DO objective*. But, because the *background DO objective* is given as year-round, daily minima, these improved fall conditions are not captured as a site-specific objective.

4.2.1.2 <u>North Coastal Basin (1B)</u>
In the North Coastal Basin (1B), the consultant assessed the available data for each Hydrologic Area and proposed the same site-specific objective for all the named waterbodies in the Basin, except Humboldt and Bodega bays. Thus, the site-specific objective for North Coastal Basin (1B) waterbodies listed in Table 3-1 is a daily

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[17] Waterbodies listed in the Basin Plan are categorized first by Hydrologic Unit, then by Hydrologic Area, sometimes by Hydrologic Subarea, and then by waterbody.

[18] This is the case except in the Middle Trinity Hydrologic Area which may inadvertently have been excluded from Table 3-1.

minimum of 7.0 mg/L DO, except in Humboldt and Bodega bays where the objective is 6.0 mg/L DO as a daily minimum.

Different from the Klamath Basin (1A), in the North Coastal Basin (1B) only the mainstem rivers within each Hydrologic Area are named and assigned a site-specific DO objective. Tributaries are not named nor are many important smaller coastal rivers. Indeed, none of the waterbodies within the Trinidad Hydrologic Area, North Fork Eel River Hydrologic Area, Point Arena Hydrologic Area, and Russian Gulch Hydrologic Area are included in Table 3-1. As a result, the *life cycle DO objectives* apply in numerous waters from the North Coastal Basin (1B). As above, North Coastal Basin (1B) rivers listed in Table 3-1 are assigned a daily minimum DO objective of 7.0 mg/L even during periods of salmonid embryo and larval development when a minimum of 9.0 mg/L DO may be necessary. It appears that during the spawning season, background conditions (as measured by DWR and its partners) within Basin 1B, as with Basin 1A, generally achieved DO concentrations greater than required by the *background DO objective*. But, because the *background DO objective* is given as year-round, daily minima, these improved fall conditions are not captured as a site-specific objective

4.2.1.3 Use of Grab Samples

During the 1950s and 1960s, county, state and federal partners were collecting water quality data throughout the State, including in the North Coast Region. Beginning in 1951, the Department of Water Resources (DWR) began publishing annual bulletins on the State's surface water quality resulting by the 1970s in an impressive database from which to develop water quality objectives. The DO data acquired from this effort were derived from grab samples collected during the daylight hours and analyzed in the field using the modified Winkler method (see 4.2.2 below).

Percent DO saturation was also calculated, although the method used was not well described. It appears that DO concentration, stream temperature, and station elevation were used in the calculation[19].

Grab sample data represents a single moment in time, which may not be adequate for a metric such as DO which fluctuates based on a diel cycle[20]. Even hourly grab samples at a given site (unless collected around the clock) can not ensure a clear depiction of the daily minimum DO value. This is because the daily minimum DO value is most likely to occur during the pre-dawn hours of the early morning before the work day begins. This is particularly the case for waterbodies in which there is significant photosynthetic activity. It is less the case in waterbodies or river reaches where aquatic plants, algae, or cynobacteria are generally absent.

4.2.1.4 Background vs. Natural Background

[19] Elevation can be used as a surrogate for atmospheric pressure. But, atmospheric pressure is the more accurate metric for calculating percent DO saturation because it varies with weather conditions.
[20] A 24-hour cycle.

The Basin Plan generally prohibits point source waste discharge to waterbodies in the North Coast Region except in the Mad, Eel, and Russian rivers during the wet season (October 1 through May 14). As such, Table 3-1 of the Basin Plan is designed to maintain background conditions. But, the data upon which these background conditions are based were collected during a period of time when numerous *nonpoint* source discharges were occurring, including nonpoint source discharges from agriculture, silviculture, mining, and other activities.

It is important to note that the Table 3-1 site-specific objectives do not represent *natural* background conditions. They represent the background conditions found in the listed waterbodies prior to the adoption of the first Basin Plan. Further, as a general matter, they do not represent conditions in which aquatic organisms historically existed. As such, they do not have any particular relevance to the question of species protection or the capacity of a waterbody to maintain conditions of DO saturation.

4.2.2 Improved Data Collection Methods

Dissolved oxygen measurements were historically collected as grab samples and analyzed in the field using the Winkler or modified Winkler method. The method requires careful sampling to avoid aeration, acid fixation, and slow titration to measure a change in test color. One sample per site was typically collected during a sampling trip with site sample times varying across the hours of the work day.

More recently, DO has been measured using a datasonde data logger (datasonde). The Regional Board, for example, owns several datasondes used both by Regional Board staff and other local partners for specific field studies. A datasonde measures the current resulting from the electrochemical reduction of oxygen diffusing through a selective membrane (http://www.hydrolab.com/beta/products/d_oxygen.asp, retrieved May 20, 2008). It is capable of collecting and storing data at intervals over several days. There are issues with calibration drift and biofouling of the membrane when the device is deployed for multiple days, making quality assurance a particularly important aspect of the data collection effort. The advantage of the datasonde over the Winkler method is that data can be collected over a 24-hour period (or longer). Thus, with this sampling method, it is possible to ascertain the true daily minimum DO value.

Even more recently, dissolved oxygen data collection methods have improved yet again with the development of Luminescent Dissolved Oxygen technology. The use of this new technology is not yet widespread. But, it is expected to replace the earlier membrane-based probes in the coming year (Fadness, personal communication 6/2/08). Luminescent Dissolved Oxygen technology has a thicker membrane than its predecessor and is thus less susceptible to biofouling. It is also reported to have the ability to hold a calibration without drift (http://www.hydrolab.com/products/ldo_sensor.asp, retrieved May 21, 2008). Data can be collected with this device at intervals over a 7-day period (or longer), thus allowing for assessment not only of the daily minimum, but daily and weekly averages, as well.

4.2.3 Measuring Compliance

Measuring compliance with an ambient water quality objective requires that 1) there be an entity responsible for collecting ambient water quality data and 2) the data collected is of a type and quality appropriate for comparing to the objective in question.

4.2.3.1 Source of Monitoring Data

The measurement of compliance with an ambient water quality objective such as DO generally comes from one of three sources. It is either collected as part of an area-wide or regional ambient water quality monitoring effort, such as the Surface Water Ambient Monitoring Program (SWAMP); as an element of a special study; or as a requirement of a federal or State discharge permit.

In an earlier era local, state, and federal partners invested a significant portion of their budgets to the collection of ambient water quality data. In more recent years, however, this has been significantly reduced. The result is that on a region wide basis there is only a minor amount of ambient DO data currently being collected.

There have been in recent years, however, special studies that have resulted in more substantial quantities of ambient water quality data. With respect to the Regional Board, these special studies are generally associated with the development of a TMDL. A prime example with respect to DO, is the Klamath River TMDL in which not only has a significant amount of DO data been collected; but, computer model simulations have been run to estimate DO conditions under various scenarios, including under natural conditions. This study is described in more detail in Section IV. 2.4. below.

Finally, because of the general prohibition against point source waste discharge in North Coast waterbodies (except in the Mad, Eel, and Russian rivers), there is little ambient DO data resulting from the implementation of discharge permits.

4.2.3.2 Quality of Monitoring Data

Compliance data must be of a type and quality suitable for comparison to a water quality objective for an assessment of compliance to be reasonably possible. With respect to DO, the quality of data available through the use of datasondes has outstripped that of the *background DO objectives* that were derived from monthly grab samples. The result is that datasonde data provides a level of accuracy that did not exist at the time that the *background DO objectives* were developed.

Prior to the use of datasondes for ambient water quality monitoring, compliance was measured using grab samples. These data were directly comparable to the *background DO objectives* because they were collected in the same manner, during the same period of the day, and achieved the same level of accuracy as represented by the *background DO objectives*. Comparison of data collected by datasondes to *background DO objectives*, however, is of lesser use.

4.2.4 Klamath River TMDL

Regional Board staff is developing a DO TMDL for the Klamath River mainstem because ambient water quality DO data indicates that current conditions do not meet the *background DO objectives*. Water quality modeling further indicates that even under *natural conditions*, ambient DO concentrations do not meet *background DO objectives*. This has led to the question of whether or not the *background DO objectives* are accurate and achievable.

The headwaters of the Klamath River gather in the Modoc Plateau, an area of geologically young lava flows (Pliocene and Pleistocene – less than fifteen million years) and flat valleys punctuated by volcanic cones. The rolling valley bottoms are at about 4000 to 5000 feet elevation and the volcanic cones rise a thousand feet higher. While drainage in this young landscape is through-flowing, many depressions contain shallow lakes. Although rainfall is low, the flat and rolling valley bottoms of rich volcanic and organic soils combine with abundance of water entering from higher surrounding country to create historically vast freshwater wetlands. The volcanic soils are naturally rich in phosphorus, a nutrient of concern in the DO TMDL.

The naturally high nutrient content of the volcanic soils, as well as the shallow topography of the upper basin, serve to feed periodic algae and cynobacteria blooms downstream in the Klamath River mainstem. This creates extreme DO diel cycles during a given bloom season, thereby exceeding the existing *background DO objective* of 7.0 mg/L DO above Iron Gate Dam and 8.0 mg/L DO below Iron Gate Dam. Indeed, simply due to natural background temperatures, salinity and elevation, DO saturation under natural conditions is sometimes less than the *background DO objective* (see Figures 4-1 and 4-2)

Figure 4-1: Upstream of Iron Gate Reservoir – T1BS – Natural Conditions / Baseline TMDL Model Scenario – DO Saturation is 100%

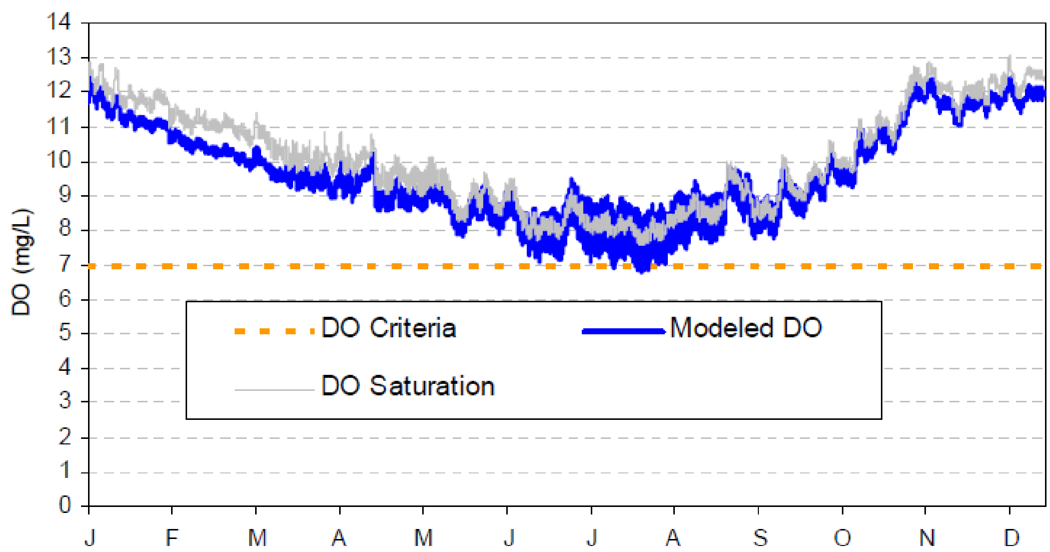
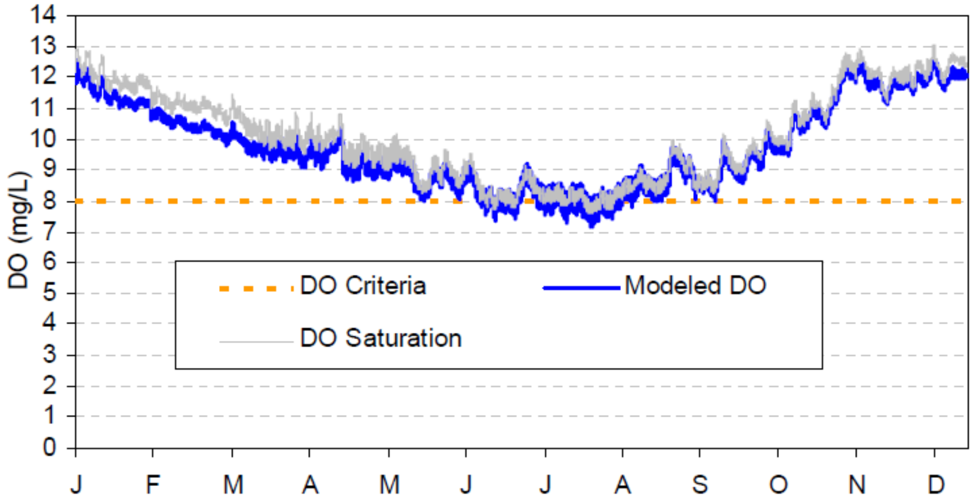


Figure 4-2: Downstream of Iron Gate Reservoir – T1BS – Natural Conditions / Baseline TMDL Model Scenario – DO Saturation is 100%



The *background DO objectives* for the Klamath River mainstem are based on grab sample data collected at various locations upstream and downstream of Iron Gate Dam subsequent to the installation of the dams. As such, the data incorporates the existence of the dams, the other anthropogenic activities occurring at the time of sampling (e.g. mining, silviculture, and agriculture), as well as the natural phenomena of elevated nutrient and organic matter loading. Further, as described elsewhere, the *background DO objectives* for the Klamath River represent DO conditions based on conditions found during daylight hours. Because they are given as daily minima, datasonde DO data (i.e., data collected automatically at intervals over a 24-hour period or longer) will periodically result in minima less than the objectives during the summer months when pre-dawn DO values drop below expected day-time concentrations.

4.2.5 Staff's Preliminary Proposals

In conclusion, the *background DO objectives* appear to have several issues requiring correction through the adoption of revised water quality objectives for DO. For example, the existing *background DO objectives* do not appear to provide adequate protection for all times of the year because they are given as year-round daily minima, rather than seasonal criteria. The existing *background DO objectives* are based on monthly grab sample data. These do not compare well to data derived from continuous monitoring datasondes. The *background DO objectives* are of differing levels of site-specificity (e.g., Basin 1A objectives vs. Basin 1B objectives). Finally, the existing ambient water quality database for DO concentration is spotty, at best. With little existing DO data for most waterbodies, it would be difficult to simply update the existing *background DO objectives* as they are currently derived.

As such, these are staff's proposals resulting from its preliminary assessment of the *background DO objectives*.

1. Reverse the priority of the *life cycle DO objectives* and *background DO objectives* so that *life cycle DO objectives* always apply unless natural conditions prevent

their attainment. Define the term "natural conditions" so as to rationally identify those waterbodies where the *life cycle DO objectives* are unattainable[21].

2. Allow for the development of new site-specific background DO objectives for waterbodies in which the *life cycle DO objectives* are unattainable. Provide a method for developing these new site-specific background DO objectives. (See Section 4.3). In this way, reduce the number of waterbodies for which site-specific background DO objectives are necessary.
3. Eliminate from Table 3-1, *background DO objectives* for all listed waterbodies except: the Lost River Hydrologic Area, Humboldt Bay, and Bodega Bay. Retain the *background DO objectives* for the Lost River because a DO TMDL has been developed for the Lost River using the existing *background DO objective* as its basis. Implementation of the Lost River TMDL should proceed before seeking to alter the water quality objective. Retain the *background DO objectives* for Humboldt Bay and Bodega Bay unless a *life cycle DO objective* is developed for EST that clarifies the relationship between estuarine DO saturation and the life cycle requirements of smolts.

4.3. Estimating Background DO Conditions

There are several difficulties in estimating background DO conditions that have to do with the fluctuating nature of DO. First, as described above, DO concentration fluctuates due to changes in DO saturation—or the capacity of water to hold oxygen in a soluble state. Second, DO concentration fluctuates due to changes in the proportion of DO saturation that is actually utilized (% saturation). Third, DO concentrations fluctuate spatially and temporally throughout a waterbody. Finally, the temporal and spatial fluctuation in DO concentration has both natural and anthropogenic causes. Thus, to accurately estimate background DO conditions requires that each of these modes of fluctuation be accounted for and considered. This is no truer than now when the specter of global warming and its effects on water quality are of prime concern.

Regional Board staff preliminarily assessed two different approaches to the problems associated with the existing *background DO objectives.* First, staff considered using the water quality modeling results of the Klamath River DO TMDL effort as the basis for revising *background DO objectives* in the Klamath River and the water quality modeling technique as the basis for revising *background DO objectives* in other North Coast rivers that can not meet *life cycle DO objectives* due to natural conditions. Second, staff considered using the temperature modeling results/techniques developed for temperature TMDLs in the North Coast Region in concert with fixed % saturation as the basis for revised *background DO objectives* in those North Coast rivers that cannot meet *life cycle DO objectives* due to natural conditions. What follows is a preliminary assessment of each technique and staff's proposal for a method to estimate revised *background DO objectives* for those waterbodies in which *life cycle DO objectives* are unattainable due to natural conditions.

4.3.1 Klamath River Water Quality Modeling

[21] The term "unattainable" here means not achievable due to natural conditions.

To support TMDL development for the Klamath River system, the need for an integrated receiving water hydrodynamic and water quality modeling system was identified. A model for the Klamath River had already been developed by PacifiCorp to support studies for the Federal Energy Regulatory Commission Hydropower relicensing process (Watercourse Engineering, Inc. 2004) when this project commenced. The version of the model available in 2004 is hereafter referred to as the *PacifiCorp Model*. The Regional Board, Oregon Department of Environmental Quality (ODEQ), and USEPA determined that this existing *PacifiCorp Model* would provide the optimal basis, after making some enhancements, for TMDL model development. The *PacifiCorp Model* uses hydrodynamic and water quality models with a proven track record in the environmental arena and has already been reviewed by most stakeholders in the watershed. Additionally, it can be directly compared to ODEQ, Regional Board and Tribal water quality criteria.

4.3.1.1 <u>Description of the Model</u>

The original *PacifiCorp Model* consisted of Resource Management Associates (RMA) RMA-2 and RMA-11 models and the U.S. Army Corps of Engineers' CE-QUAL-W2 model. The RMA-2 and RMA-11 models were applied for Link River (which is the stretch of the Klamath River from Upper Klamath Lake to Keno Dam), Keno Dam to J.C. Boyle Reservoir, Bypass/Full Flow Reach, and Iron Gate Dam to Turwar. RMA-2 simulates hydrodynamics while RMA-11 represents water quality processes. The CE-QUAL-W2 model was applied for Lake Ewauna-Keno Dam, J.C. Boyle Reservoir, Copco Reservoir, and Iron Gate Reservoir. CE-QUAL-W2 is a two-dimensional, longitudinal/vertical (laterally averaged), hydrodynamic and water quality model (Cole et al. 2000). Enhancements to the RMA/CE-QUAL-W2 portions of the model were made in the following areas: BOD/organic matter (OM) unification, algae representation in Lake Ewauna, Monod-type continuous Sediment Oxygen Demand (SOD) and OM decay, pH simulation in RMA, OM-dependent light extinction simulation in RMA, reaeration formulations, and dynamic OM partitioning.

Since the estuarine portion of the Klamath River (Turwar to the Pacific Ocean) was not included in the original *PacifiCorp Model*, one of the first updates made was to include an estuarine model. From a review of available data for the estuary, it was apparent that hydrodynamics and water quality within the estuary are highly variable spatially and throughout the year and are greatly influenced by time of year, river flow, tidal cycle, and location of the estuary mouth (which changes due to sand bar movement). Additionally, transect temperature and salinity data in the lower estuary showed significant lateral variability, as did DO to a lesser extent. Therefore, USEPA's Environmental Fluid Dynamics Code (EFDC), which is a full 3-D hydrodynamic and water quality model, was selected to model the complex estuarine environment.

EFDC is capable of predicting hydrodynamics, nutrient cycles, DO, temperature, and other parameters and processes pertinent to the TMDL development effort for the estuarine section. It is capable of representing the highly variable flow and water quality conditions within years and between years for the estuary. As with RMA-2, RMA-11, and CE-QUAL-W2, EFDC has a proven record in the environmental arena and model results can be directly compared to ODEQ, NCRWQCB and Tribal water quality criteria. A major advantage of EFDC is that it is USEPA-endorsed and supported and available freely in the public domain.

The combination of the *PacifiCorp Model* (RMA and CE-QUAL-W2), with enhancements, and the EFDC model for the estuary resulted in the Klamath River model used for TMDL development. Table 4-1 identifies the modeling elements applied to each river segment. These segments are depicted graphically in Figures 4-3 and 4-4. Linkages between the different modeling segments were made by transferring time-variable flow and water quality from one model to the next (e.g., output from the Link River model became input for the Lake Ewauna-Keno Dam model).

Table 4-1: Models applied to each Klamath River and estuary segment

Modeling Segment #	Modeling Segment	Segment Type	Model(s)	Dimensions
1	Link River	River	RMA-2/RMA-11	1-D
2	Lake Ewauna-Keno Dam	Reservoir	CE-QUAL-W2	2-D
3	Keno Dam to J.C. Boyle Reservoir	River	RMA-2/RMA-11	1-D
4	J.C. Boyle Reservoir	Reservoir	CE-QUAL-W2	2-D
5	Bypass/Full Flow Reach	River	RMA-2/RMA-11	1-D
6	Copco Reservoir	Reservoir	CE-QUAL-W2	2-D
7	Iron Gate Reservoir	Reservoir	CE-QUAL-W2	2-D
8	Iron Gate Dam to Turwar	River	RMA-2/RMA-11	1-D
9	Turwar to Pacific Ocean	Estuary	EFDC	3-D

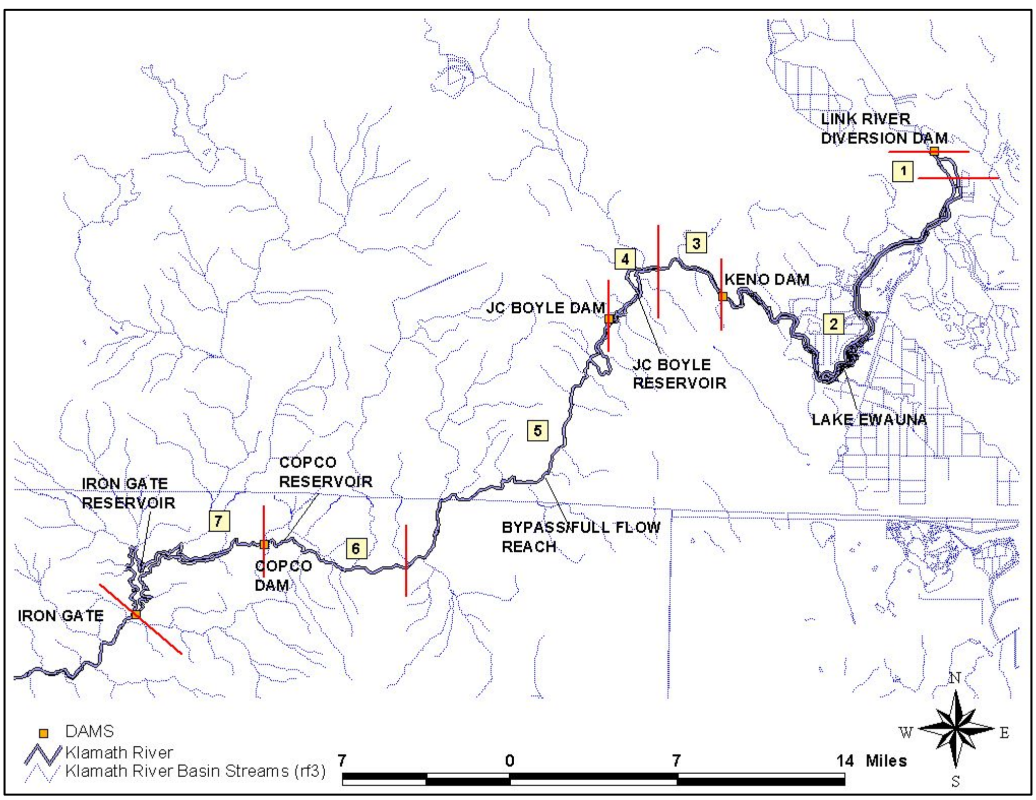


Figure 4-3: Model segments in Oregon and Northern California

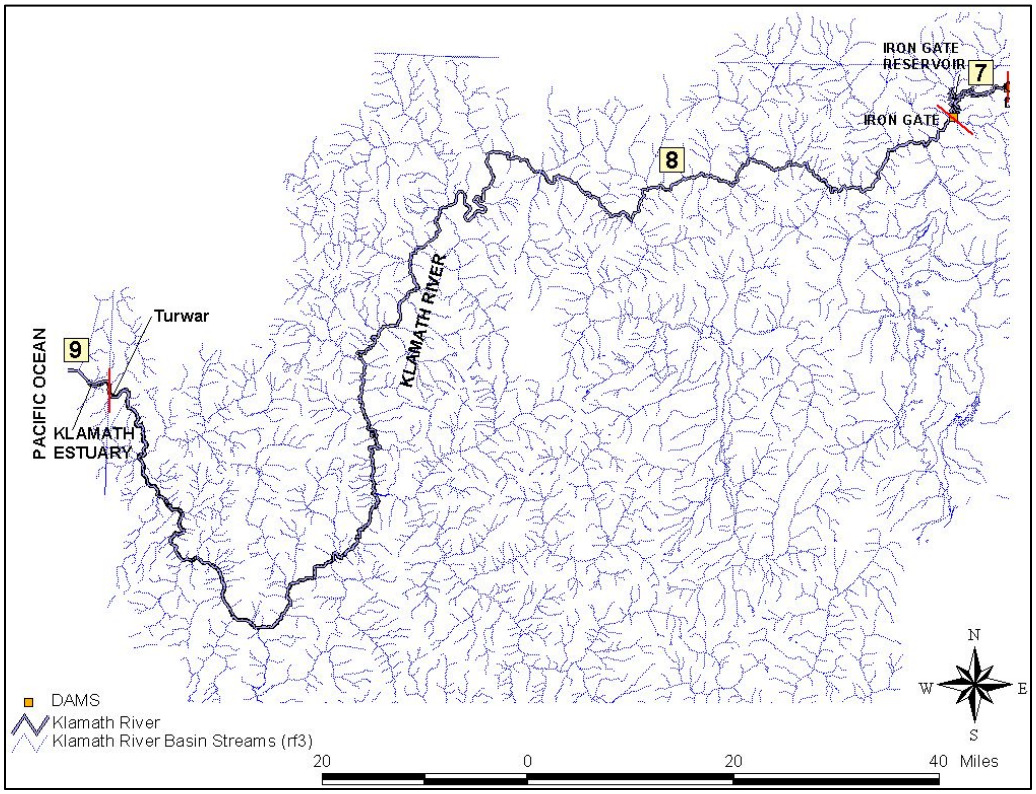


Figure 4-4: Model segments in California

The model was run to simulate DO concentrations under natural conditions (i.e., T1BS). Variables were adjusted and natural boundary conditions estimated for this simulation. Most importantly, the T1BS model run simulates a free-flowing river without any dams. The result of the T1BS model run is the indication that under natural stream conditions, DO concentrations in the Klamath River mainstem are sometimes less than the *background DO objective*. Further, as demonstrated by Figure 4- 2 above, DO conditions under full saturation also do not consistently meet the *background DO objectives*.

4.3.1.2 <u>Use of the Model to generate DO objectives</u>
Regional Board staff first considered using the results of the T1BS model run as the basis for revised *background DO objectives* for the Klamath River mainstem. The appeal of this approach is that new objectives for the Klamath River could proceed in concert with the development of the TMDL. The science could be reviewed for both efforts at the same time. The adoption of revised DO objectives for the Klamath could naturally occur on a schedule to support completion of the TMDL. In addition, the models used are well respected and the effort to date, widely reviewed.

On the other hand, Regional Board staff observe that the economic and staff resources necessary to develop and run the model for the Klamath River far exceeds that which is available for correcting the *background DO objectives* in the other Table 3-1 waterbodies. Further, the amount and quality of data necessary to run the model is unavailable in most of the rest of the waterbodies in the North Coast.

4.4. Natural Temperatures and Percent DO Saturation

Recognizing the inaccuracies of the existing *background DO objectives* has allowed staff to reconsider the format with which to express any new *background DO objectives* that might be developed. One obvious possibility is to utilize a form that incorporates the inherent variability of DO while still providing an objective that is rationale and measurable. Back in the 1960s and 1970s when water quality objectives were first being developed, a debate took place in the scientific literature regarding the question of whether DO criteria are better established as fixed concentration limits or as dynamic criteria, such as % DO saturation. Those arguing in favor of % DO saturation, for example, noted that it is the partial pressure of oxygen in the environment that controls the amount of DO an aquatic organism receives by establishing the gradient in partial pressure between the aquatic environment and an organism's arterial system. Those arguing in favor of DO concentration as the appropriate metric noted that DO concentration is far easier to measure and articulate than is % DO saturation. They also argued that concentration limits provide better life cycle protection than % saturation where temperatures fluctuate dramatically.

4.4.1 Other Regional Boards

All nine of the Regional Water Boards in California adopted DO concentration objectives into their Basin Plans in the 1970s. Five of the 9 Regional Water Boards also adopted % DO saturation objectives, as well. For example, the San Francisco Bay Region established a 3-month moving median concentration not less than 80% of DO saturation. They went further in saying that "in areas unaffected by waste discharges, a level of about 85% of oxygen saturation exists." The Central Coast adopted an objective requiring that "the median value not fall below 85% saturation as a result of controllable water quality conditions." The Central Valley requires that outside of the Delta the "median of the mean daily DO concentration shall not fall below 85% of saturation in the main water mass…When natural conditions lower DO below (established concentration limits), the concentrations shall be maintained at or above 95% of saturation." The Lahontan Region requires that the "minimum DO concentration (not) be less than 80% of saturation." Finally, the Santa Ana Region requires that "waste discharges shall not cause the median dissolved oxygen concentration to fall below 85% of saturation."

4.4.2 Effect of Temperature

Regional Board staff has considered designing DO saturation criteria similar to those included in the Basin Plans of other regions. Of concern to North Coast staff, however, is the role of stream temperature in the assessment of background conditions. DO saturation varies inversely with temperature. As such, in those waterbodies where stream temperature is elevated due to anthropogenic causes, DO at saturation is lower than under previously cooler conditions. A % saturation criteria applied to a waterbody impaired by elevated temperatures, then, will in essence be allowing or condoning the temperature-related reduction in DO. To correct this possibility, Regional Board staff has considered applying a % saturation criteria based not on *existing* stream temperatures but, an estimate of *natural* stream temperatures.

Fluctuations in DO saturation due to variation in salinity and atmospheric pressure are presumed for the purposes of this preliminary assessment to be related to natural causes such as tidal flux and storm systems, respectively.

Another effect of increased temperature is to cause an increase in the rate of metabolic activity in salmonids and other aquatic organisms. Thus, as temperature rise, their need for food increases as does their need for oxygen to fuel the increased rate of metabolism. Yet, as temperatures increase, the DO concentration at saturation decreases, thereby putting aquatic organisms into a state of physiological stress. Tying the calculation of background DO conditions based on % saturation to natural temperatures serves to limit the effect of this phenomenon. Further, it better highlights for waterbodies unable to meet *background DO objectives* based on natural temperatures the need for both DO *and* temperature controls.

4.4.3 Identifying Appropriate % Saturation

The premise for using % saturation (and natural temperatures) as the basis for a DO objective is that in a healthy aquatic system, DO concentrations fluctuate within a relatively narrow range around the saturation point. The question is how to numerically define the "narrow range."

The San Francisco Regional Water Quality Control Board (Region 2) estimates that water unaffected by waste discharge achieves 85% saturation (SFRWQCB Basin Plan). In addition, Dr. Peter Moyle estimates that DO levels are usually 85-100% of saturation in rivers (Moyle, personal communication May 12, 2007). The Technical Advisory Committee of ODEQ in their review of ODEQ's water quality standards conclude that "the 'natural' conditions in some streams will cause dissolved oxygen levels to fall below…the conservative 90-95 percent criteria when interpreted as absolute minimums (ODEQ, 1995)."

Other researchers have estimated the % DO saturation necessary for the protection of the aquatic resources, particularly salmonids. For example, Bjornn and Reiser (1991) recommend a minimum of 80% saturation for the protection of spawning fish. They cite Doudoroff and Warren (1965) as determining that when DO is below saturation throughout development, embryos are smaller than usual and hatching is delayed or premature. Bjornn and Reiser (1991) recommend that DO concentrations be at or near saturation for successful incubation. Davis (1975) recommends that salmonids require 85% saturation at temperatures of 20ºC (68ºF) and no less than 76% saturation at temperatures of 15ºC (59ºF) or less. Salmonid larvae and mature eggs, on the other hand, require 100% saturation at temperatures of 20ºC (68ºF) and no less than 98% saturation at temperatures of 15ºC (59ºF) or less. National Rivers Authority of Great Britain defines "very good habitat, suitable for all fish" as achieving 80% saturation (National River Authority 1994).

Regional Board staff has not yet analyzed all the DO data available for the Region. But, a spot check of data compiled by DWR shows a range of day-time saturations in North Coast waterbodies from 62-149% with the majority of values ranging from 90-110% (DWR 1965). These values are day-time values and represent water quality conditions resulting from few point source waste discharges but numerous nonpoint source waste discharges.

Staff's preliminary proposal

1. Use 85% saturation, based on an estimate of natural temperatures, as the *background DO objective* for those water bodies unable to meet the *life cycle DO objectives* due to natural conditions. Apply the *background DO objective* calculated by this method as a daily minimum. Calculate at least two separate daily minima (i.e., wet season and dry season). But, allow for additional daily minima to be calculated, as necessary. Staff specifically solicits public input on the question of how the year should be divided to ensure adequate seasonal protection.
2. Describe the allowable methods for estimating natural temperature. Staff recommends the use of historic data, where available; analysis of site potential for shade production; or water quality models, such as SSTEMP or CE-QUAL-W2. Staff also solicits public input on the question of appropriate methods.
3. The Executive Officer should have approval authority over any method proposed for use by a discharger for the purpose of estimating natural temperatures.
4. With each ambient DO datum collected, data analysis should include the DO concentration in mg/L; % saturation based on site temperature, salinity, and atmospheric pressure; and, DO concentration at 85% saturation based on the estimate of natural temperature, site salinity, and site atmospheric pressure.
5. Where appropriate and at the Executive Officer's discretion, the estimate of natural temperature should allow for the effects of global warming.
6. To ensure protection against acute effects in COLD waterbodies, a 6.0 mg/L DO limit should be established as an absolute minimum.

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CHAPTER V. PROPOSED REVISIONS TO DO OBJECTIVE

Included here is a compilation of each of staff's proposals as given in Chapter IV.

To update the *life cycle DO objectives, staff proposes to:*

1. Retain 5.0 mg/L DO as a daily minimum as the *life cycle DO objective* for MAR and SAL to protect against acute and chronic effects on salt water species.
2. Add a phrase clarifying that the *life cycle DO objective* for SPWN is designed to protect freshwater ecosystems. It is not intended to apply in saline environments.
3. Specifically solicit pubic input on the question of whether or not a DO objective designed to protect spawning and early life stages in saline environments is necessary. Request data and other information with which such an objective could be developed, if necessary.
4. Retain 5.0 mg/L DO applied as a daily minimum as the *life cycle DO objective* for WARM to protect against acute and chronic effects on juvenile and adult warm water species and acute effects on early life stages of warm water species.
5. Consider adding 6.0 mg/L applied as a 7-day moving average as the *life cycle DO objective* for SPWN to protect against chronic effects in early life stages of warm water species. The 7-day moving average should be calculated using seven consecutive daily means. Daily means should be calculated based on at least the minimum and maximum daily DO values; but, preferably based on data collected less than or equal to every hour over a 24 hour day. Consider adding a phrase that the *life cycle DO objective* for SPWN to protect against chronic effects on early life stages of warm water species only applies where and when the spawning, egg incubation, or larval development of warm water species is present or was historically present.
6. Retain 6.0 mg/L DO applied as a daily minimum as the *life cycle DO objective* for COLD to protect against acute effects on juvenile and adult cold water species.
7. Add 8.0 mg/L as a 7-day moving average as the *life cycle DO objective* for COLD to protect against chronic effects on juvenile and adult cold water species. The 7-day moving average should be calculated using seven consecutive daily means. Daily means should be calculated based on at least the minimum and maximum daily DO values; but, preferably based on data collected at intervals less than or equal to every hour over the course of a 24 hour day. Staff recommends a 7-day moving average as better than a 30-day moving average for the protection of salmonids because it is more protective.
8. Add a phrase that acknowledges that COLD objectives are specifically designed to protect salmonids; but extend to other less sensitive cold water organisms, as well.
9. Retain 9.0 mg/L DO applied as a daily minimum as the *life cycle DO objective* for "SPWN during critical spawning and egg incubation periods" to protect against acute effects on early life stages of cold water species. Rename this objective "SPWN." Clarify that this objective is designed to protect fresh cold water species, only. It is not intended to apply to saline or warm water ecosystems. Add a phrase that SPWN is to be applied in current and historic salmonid spawning habitat when spawning is or has historically occurred. Reference historic records, maps, and/or data produced by the National Marine Fisheries

Service, U.S. Fish and Wildlife Service and California Department of Fish and Game for the purpose of determining where and when in individual waterbodies spawning is occurring or has historically occurred. Clarify that where such information is lacking, the SPWN DO objective applies throughout SPWN-designated waterbodies and during the period in which spawning, egg incubation, and larval development occurs or has historically occurred. Identify a calendar period that brackets the existing and historic early life stages of North Coast salmonid species.

10. Add 11.0 mg/L applied as a 7-day moving average as the *life cycle DO objective* for SPWN to protect against chronic effects on early life stages of cold water species. The 7-day moving average should be calculated using seven consecutive daily means. Daily means should be calculated based on at least the minimum and maximum daily DO values; but, preferably based on data collected at intervals less than or equal to every hour over the course of a 24 hour day. Extend the period of time in which SPWN applies to include not only spawning and egg incubation, but larval development, as well.
11. Eliminate the 7.0 mg/L daily minimum SPWN DO objective as redundant, unnecessary, and under protective during larval stages.
12. Do not add a *life cycle DO objective* for MIGR. Rely instead on the DO objectives for COLD to provide adequate protection for MIGR, as well.
13. Specifically solicit pubic input on the question of whether or not a DO objective designed to protect the estuarine needs of smolts is necessary. Request data and other information with which such an objective could be developed.

To update and improve the use of *backgound DO objectives*, staff proposes to:

1. Reverse the priority of the *life cycle DO objectives* and *background DO objectives* so that *life cycle DO objectives* always apply unless natural conditions prevent their attainment. Define the term "natural conditions" so as to rationally identify those waterbodies where the *life cycle DO objectives* are unattainable[22].
2. Allow for the development of new site-specific background DO objectives for waterbodies in which the *life cycle DO objectives* are unattainable. Provide a method for developing these new site-specific background DO objectives. In this way, reduce the number of waterbodies for which site-specific background DO objectives are necessary.
3. Eliminate from Table 3-1, *background DO objectives* for all listed waterbodies except: the Lost River Hydrologic Area, Humboldt Bay, and Bodega Bay. Retain the *background DO objectives* for the Lost River because a DO TMDL has been developed for the Lost River using the existing *background DO objective* as its basis. Implementation of the Lost River TMDL should proceed before seeking to alter the water quality objective. Retain the *background DO objectives* for Humboldt Bay and Bodega Bay unless a *life cycle DO objective* is developed for EST that clarifies the relationship between estuarine DO saturation and the life cycle requirements of smolts.

[22] The term "unattainable" here means not achievable due to natural conditions.

4. Use 85% saturation, based on an estimate of natural temperatures, as the *background DO objective* for those water bodies unable to meet the *life cycle DO objectives* due to natural conditions. Apply the *background DO objective* calculated by this method as a daily minimum. Calculate at least two separate daily minima (i.e., wet season and dry season). But, allow for additional daily minima to be calculated, as necessary. Staff specifically solicits public input on the question of how the year should be divided to ensure adequate seasonal protection.
5. Describe the allowable methods for estimating natural temperature. Staff recommends the use of historic data, where available; analysis of site potential for shade production; or water quality models, such as SSTEMP or CE-QUAL-W2. Staff also solicits public input on the question of appropriate methods.
6. The Executive Officer should have approval authority over any method proposed for use by a discharger for the purpose of estimating natural temperatures.
7. With each ambient DO datum collected, data analysis should include the DO concentration in mg/L; % saturation based on site temperature, salinity, and atmospheric pressure; and, DO concentration at 85% saturation based on the estimate of natural temperature, site salinity, and site atmospheric pressure.
8. Where appropriate and at the Executive Officer's discretion, the estimate of natural temperature should allow for the effects of global warming.
9. To ensure protection against acute effects in COLD waterbodies, a 6.0 mg/L DO limit should be established as an absolute minimum.

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CHAPTER VI. IMPLEMENTATION PLAN

As above, the measurement of DO provides an excellent means of assessing the general health of a waterbody. However, the existing DO objectives do not make full use of the power of DO as a tool for this purpose. Staff intend for the revision of the DO objectives to set in place a scheme through which the collection and analysis of DO data results in meaningful assessment of water quality conditions. There are several ways in which this can be done.

1. DO monitoring methods could be improved, particularly with respect to permitted discharges.
2. Permits should be written for discharges with effects on DO.
3. Enforcement actions should be taken where discharges fail to meet DO objectives.
4. Waterbodies not meeting DO objectives should be listed on the 303(d) list and TMDLs written to correct the problem. There are currently 3 waterbodies listed on the 303(d) list for DO impairment. A TMDL for the Shasta River has been approved and is now being implemented. And, TMDLs for the Klamath River and the Laguna de Santa Rosa are currently being developed.
5. Staff will propose land management strategies for controlling discharges effecting DO. They will include many of the same strategies already developed by the Regional Board for controlling temperature, nutrient, and sediment impairments. Staff specifically solicit public input on implementation measures necessary to ensure the protection of ambient DO concentrations and % saturation sufficient to protect public resources.

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CHAPTER VII. MONITORING PLAN

Monitoring is required to determine the environmental condition of a waterbody, its ability to support beneficial uses, and the degree of compliance with the Basin Plan, including water quality objectives. With respect to the proposed revisions to the Basin Plan for DO, monitoring should include measurements for:

1. DO, temperature, and salinity in the water column and
2. Atmospheric pressure at water column measuring stations.

Water quality data generally are collected in the region for one of three purposes: 1) to measure compliance with a discharge permit, 2) to identify water quality impairments requiring 303(d) listing, or 3) as a part of a specific study.

Regional Board staff issue National Pollutant Discharge Elimination System (NPDES) permits as well as Waste Discharge Requirements (WDR) for the control of both point source and stormwater discharges. Instream DO measurements are required upstream and downstream of a discharge. The upstream measurement is intended to represent ambient conditions while the downstream measurement is intended to reflect the impact of the discharge on the ambient condition. A violation of the water quality objectives results if the upstream measurement meets the water quality objective and the downstream measurement does not; or, if the upstream measurement does not meet the water quality objective and the downstream measurement is less than the upstream measurement. Staff recommend that:

1. DO measurements be continuous measurements collected less than or equal to once every hour within a 24-hour day. A reasonable break in the monitoring schedule should be allowed for the purpose of maintaining or replacing monitoring equipment.
2. DO weekly averages be calculated from the daily means of a moving 7-day period. Fewer than 7 daily means may be allowable in any 7-day period for the calculation of a weekly average to be acceptable. Staff specifically solicit public input on this question.
3. The period of monitoring be adjusted based on site specific information indicating that less frequent monitoring will provide equivalent results.
4. Upstream monitoring be outside the sphere of influence of the discharge in question. It should also be outside the influence of any other known upstream point source discharges, if possible.
5. Downstream monitoring be established downstream of the discharge outfall a sufficient distance to ensure that the effects on DO of the discharge (e.g., conversion of organic matter, uptake of nutrients) are adequately captured. This determination may require a short field trial or simple modeling exercise.

Regional Board staff also implement the Surface Water Ambient Monitoring Program (SWAMP) in the North Coast Region. Annual data, including DO data, is collected from individual watersheds on a rotation. The SWAMP program maintains several datasondes and is capable of collecting continuous measurements over multiple days.

The data collected through SWAMP are used, in conjunction with data from other sources, to assess the condition of the Region's waterbodies, including the identification of waterbodies that are impaired and require listing on the Clean Water Act (CWA) 303(d) list. There are three waterbodies in the North Coast Region currently listed on the 303(d) list for impairments due to reduced DO: the Klamath River mainstem from the Oregon border to the estuary, the Shasta River Hydrological Area, and Laguna de Santa Rosa in the Russian River watershed. A Total Maximum Daily Load (TMDL) to correct the problem has been developed and adopted for the Shasta River. TMDLs for the Klamath River and Laguna de Santa Rosa are currently under development.

There are numerous other waterbodies in the Region, however, that are listed as impaired due to excess nutrients, elevated stream temperatures, and/or pH. These are indicators that often result in or are suggestive of excessive primary production and may impact DO concentration and saturation. These require further monitoring. Staff recommend that:

1. A North Coast database for ambient water quality should include all sources of relevant data, including ambient data collected by dischargers under their NPDES permit or WDR.
2. Waterbodies with impairments due to pH, ammonia, temperature, or nutrients should also be monitored for DO.
3. As above, DO monitoring should be conducted on a continuous basis with measurements recorded less than or equal to once every hour within a 24-hour day and for at least a 7-day period. Simultaneously, temperature, salinity, and atmospheric pressure should also be collected to allow for the calculation of percent DO saturation.
4. SWAMP should develop and distribute amongst Regional Board staff and permit holders guidelines for the appropriate placement of monitoring devices for the purpose of ensuring the collection of representative samples.

Finally, Regional Board staff and/or its cooperators occasionally conduct special water quality studies, which result in the collection of DO data or modeling. Such special studies might include investigations and analysis to: respond to complaint; support an enforcement action; support the 303(d) listing process; support the development of a TMDL; or otherwise determine compliance with the Basin Plan, permit, or TMDL. Occasionally, Regional Board staff participate in area-wide monitoring projects led by another agency, but including a water quality goal, which we serve. Staff recommend that:

1. Data collected under these auspices be included in a Region-wide ambient water quality database for future reference and analysis.
2. DO data be collected in a manner consistent with the proposed DO objective, including the percent DO saturation criteria, if adopted.

CHAPTER VIII. CEQA

The adoption of a revised DO objective must comply with the California Environmental Quality Act (CEQA). A staff report providing the background analysis for a Basin Plan amendment is considered functionally equivalent to a CEQA document and will be used for that purpose. The CEQA process is initiated with a public scoping meeting in which the agency collects public opinion on the appropriate scope of the project. After completion of the scoping process, staff will develop a draft Basin Plan Amendment and staff report for the Regional Board's consideration. A public workshop and hearing will be held and comment period provided to ensure the involvement of the public in the decision-making process.

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TABLE 2-1: BENEFICIAL USES OF WATERS OF THE NORTH COAST REGION

HU/HA/ HSA	HYDROLOGIC UNIT/AREA/ SUBUNIT/DRAINAGE FEATURE	BENEFICIAL USES																										
		MUN	AGR	IND	PRO	GWR	FRSH	NAV	POW	REC1	REC2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL	EST	AQUA	CUL	FLD	WET	WQE
101.00	**Winchuck River Hydrologic Unit**																											
	Winchuck River	E	E	E	P		E	E	P	E	E	E		E			E	E		E	E			P				
102.00	**Rogue River Hydrologic Unit**																											
102.20	Ilinois River Hydrologic Area	E	E	E	P		E	E	E	E	E	E		E			E	E		E	E			E				
102.30	Applegate River Hydrologic Area	E	E	E	E		E	E	P	E	E	E		E			E	E		E	E			P				
103.00	**Smith River Hydrologic Unit**																											
103.10	Lower Smith River Hydrologic Area																											
103.11	Smith River Plain Hydrologic Subarea	E	E	E	P		E	E		E	E	E		E			E	E	E	E	E		E	P	E			
	Lake Talawa	P					E	E		E	E	E	E	E			E	E		E				P	E			
	Lake Earl	E	E	E			E	E		E	E	E	E	E			E	E		E				P	E			
	Crescent City Harbor						E	E		E	E	E	P	E			E	E	E	E		E		E				
103.12	Rowdy Creek Hydrologic Subarea	E	E	E	P		E	E	P	E	E	E		E			E	E		E	E			P				
103.13	Mill Creek Hydrologic Subarea	E	E	E	P		E	E	P	E	E	E		E			E	E		E	E			P				
103.20	South Fork Smith River Hydrologic Area	E	E	E	P		E	E	E	E	E	E		E			E	E		E	E			P	E			
103.30	Middle Fork Smith River Hydrologic Area	E	E	E	P		E	E	E	E	E	E		E			E	E		E	E			E	P			
103.40	North Fork Smith River Hydrologic Area	E	E	E	P		E	E	E	E	E	E		E			E	E		E	E			P				
103.50	Wilson Creek Hydrologic Area	E	E	E	P		E	E	E	E	E	E		E			E	E		E	E			P	E			
105.00	**Klamath River Hydrologic Unit**																											
105.10	Lower Klamath River Hydrologic Area																											
105.11	Klamath Glen Hydrologic Subarea	E	E	P	P	E	E	E	P	E	E	E	E	E			E	E	E	E	E	E	E	P	E			
105.12	Orleans Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E	E	E			E	E		E	E	P		P	E			
105.20	Salmon River Hydrologic Area																											
105.21	Lower Salmon Hydrologic Subarea	E	E	E	P		E	E	P	E	E	E		E			E	E		E	E	P		P	E			
105.22	Wooley Creek Hydrologic Subarea	E	P	E	P	E	E	E	P	E	E	E		E			E	E		E	E	P		P	E			
105.23	Sawyers Bar Hydrologic Subarea	E	E	E	P		E	E	P	E	E	E		E			E	E		E	E	P		P				
105.24	Cecilville Hydrologic Subarea	E	E	E	P		E	E	P	E	E	E		E			E	E		E	E	P		P				

TABLE 2-1: BENEFICIAL USES OF WATERS OF THE NORTH COAST REGION

HU/HA/ HSA	HYDROLOGIC UNIT/AREA/ SUBUNIT/DRAINAGE FEATURE	BENEFICIAL USES																										
		MUN	AGR	IND	PRO	GWR	FRSH	NAV	POW	REC1	REC2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL	EST	AQUA	CUL	FLD	WET	WQE
105.30	Middle Klamath River Hydrologic Area																											
105.31	Ukonom Hydrologic Subarea	E	E	E	E	E	E	E	P	E	E	E	E	E			E	E		E	E			P	E			
105.32	Happy Camp Hydrologic Subarea	E	E	E	E	E	E	E	P	E	E	E	E	E			E	E		E	E			P	E			
105.33	Seiad Valley Hydrologic Subarea	E	E	E	E	E	E	E	P	E	E	E	E	E			E	E		E	E			P	E			
105.35	Beaver Creek Hydrologic Subarea	E	E	E	E	E	E	E	P	E	E	E	E	E			E	E		E	E			P				
105.36	Hornbrook Hydrologic Subarea	E	E	E	E	E	E	E	P	E	E	E	E	E			E	E		E	E			P				
105.37	Iron Gate Hydrologic Subarea	P	P	P	P		E	E	E	E	E	E	E	E			E	E		E	E	E		E				
105.38	Copco Lake Hydrologic Subarea	E	E	E	P		E	E	E	E	E	E	E	E			E	E		E	E			E				
105.40	Scott River Hydrologic Area																											
105.41	Scott Bar Hydrologic Subarea	E	E	E	P	E	E	E	E	E	E	E		E			E	E		E	E			P				
105.42	Scott Valley Hydrologic Subarea	E	E	E	P	E	E	E	E	E	E	E		E			E	E		E	E			E				
105.50	Shasta Valley Hydrologic Area																											
	Shasta River & Tributaries	E	E	E	P	E	E	E	P	E	E	E	E	E			E	E		E	E			E				
	Lake Shastina	P	E	P	P	E	E	E		E	E		E	E			E			P				P				
	Lake Shastina Tributaries	E	E	E	P	E	E	P	P	E	E	E	E	E			E			E	E			P				
105.80	Butte Valley Hydrologic Area																											
105.81	Macdoel-Dorris Hydrologic Subarea	E	E	P	P				E	E	E	E	E	E			E	E		E	E			P				
	Meiss Lake	E	E	P	P	E				P	E		E	E			E							P				
105.82	Bray Hydrologic Subarea	E	E						P	E	E	E	E				E	E		E	E			P				
105.83	Tennant Hydrologic Subarea	E	E	P	P	E	E		P	E	E	P	P	E			E	P		E	E			P				

TABLE 2-1: BENEFICIAL USES OF WATERS OF THE NORTH COAST REGION

HU/HA/ HSA	HYDROLOGIC UNIT/AREA/ SUBUNIT/DRAINAGE FEATURE	BENEFICIAL USES																										
		MUN	AGR	IND	PRO	GWR	FRSH	NAV	POW	REC1	REC2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL	EST	AQUA	CUL	FLD	WET	WQE
105.90	Lost River Hydrologic Area																											
105.91	Mount Dome Hydrologic Subarea	P	E	P	P	E	E		P	P	E	P	E	E			E	E		E	E			P				
105.92	Tule Lake Hydrologic Subarea	P	E	P	P	E	E			P	E	E	E	P			E	E		E	E			P				
105.93	Clear Lake Hydrologic Subarea	P	E	P	P	E	E	P	P	E	E	E	E	E			E	E		E	E	P		P				
105.94	Boles Hydrologic Subarea	P	E	P	P	E	E		P	P	E	E	E	E			E	E		E	E	P		P				
	Trinity River Hydrologic Unit																											
106.10	Lower Trinity River Hydrologic Area																											
106.11	Hoopa Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E	P		P	E			
106.12	Willow Creek Hydrologic Subarea	E	E	E	P	E	E	E	E	E	E	E		E			E	E		E	E	P		P				
106.13	Burnt Ranch Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E	P		E				
106.14	New River Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E	P		P				
106.15	Helena Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E	P		P				
106.20	South Fork Trinity River Hydrologic Area																											
106.21	Grouse Creek Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E			P				
106.22	Hyampom Hydrologic Subarea	E	E	E	P	E	E	P	E	E	E	E		E			E	E		E	E			P				
106.23	Forest Glen Hydrologic Subarea	E	E	E	P	E	E	P	P	E	E	E		E			E	E		E	E			P				
106.24	Corral Creek Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E			P				
106.25	Hayfork Valley Hydrologic Subarea	E	E	E	E	E	E		P	E	E	E		E			E	E		E	E			P				
	Ewing Reservoir	E		P	P			E		P	E	E	E	E			E	E						P				
106.30	**Middle Trinity Hydrologic Area**																											
106.31	Douglas City Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E			P				
106.32	Weaver Creek Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E			E				

TABLE 2-1: BENEFICIAL USES OF WATERS OF THE NORTH COAST REGION

HU/HA/ HSA	HYDROLOGIC UNIT/AREA/ SUBUNIT/DRAINAGE FEATURE	BENEFICIAL USES																										
		MUN	AGR	IND	PRO	GWR	FRSH	NAV	POW	REC1	REC2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL	EST	AQUA	CUL	FLD	WET	WQE
106.40	Upper Trinity River Hydrologic Area																											
	Trinity Lake (formerly Clair Engle Lake)	E	E	E	E	E	E	E	E	E	E	E	E	E			E	E		P	E			P				
	Lewiston Reservoir	E	E	P	P	E	E	E	E	E	E	E	P	E			E	E		P	E			E				
	Trinity River	E	E	P	P	E	E	E	P	E	E	E		E			E	E		E	E			E				
107.00	**Redwood Creek Hydrologic Unit**																											
107.10	Orick Hydrologic Area	E	E	E	P	E		E	P	E	E	E		E			E	E	E	E	E		E	P	E			
107.20	Beaver Hydrologic Area	E	E	E	P	E		E	P	E	E	E		E			E	E		E	E			P				
107.30	Lake Prairie Hydrologic Area	E	E	E	P	E		E	P	E	E	E		E			E	E		E	E			P				
108.00	**Trinidad Hydrologic Unit**																											
108.10	Big Lagoon Hydrologic Area	E	E	E	P	E	E	E		E	E	E		E	E		E	E	E	E	E		E	P	E			
108.20	Little River Hydrologic Area	P	E	E	P	E	E	E		P	E	E		E			E	E	E	E	E		E	P	E			
109.00	**Mad River Hydrologic Unit**																											
109.10	Blue Lake Hydrologic Area	E	E	E	E	E	E	E	P	E	E	E		E			E	E	P	E	E		E	E	E			
109.20	North Fork Mad River Hydrologic Area	E	E	E	E	E	E	E	P	E	E	E		E			E	E		E	E			P				
109.30	Butler Valley Hydrologic Area	E	E	E	E	E	E	E	P	E	E	E		E			E	E		E	E			P	E			
109.40	Ruth Hydrologic Area	E	E	E	E	E	E	E	E	E	E	E	E	E			E	E		E	E			P				
110.00	**Eureka Plain Hydrologic Unit**																											
	Jacoby Creek	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E*	P	E			
	Freshwater Creek	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E*	E	E			
	Elk River	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E*	P				
	Salmon Creek	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E*	P	E			
	Humboldt Bay	E	E	E	P		E	E	P	E	E	E		E			E	E	E	E	E	E	E*	E	E			

TABLE 2-1: BENEFICIAL USES OF WATERS OF THE NORTH COAST REGION

HU/HA/ HSA	HYDROLOGIC UNIT/AREA/ SUBUNIT/DRAINAGE FEATURE	BENEFICIAL USES																										
		MUN	AGR	IND	PRO	GWR	FRSH	NAV	POW	REC1	REC2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL	EST	AQUA	CUL	FLD	WET	WQE
111.00	**Eel River Hydrologic Unit**																											
111.10	Lower Eel River Hydrologic Area																											
111.11	Ferndale Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E	P	E	E	E	E	P	E			
111.12	Scotia Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E			P				
111.13	Larabee Creek Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E			P				
111.20	Van Duzen River Hydrologic Area																											
111.21	Hydesville Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E	E	E			E	E		E	E			P	E			
111.22	Bridgeville Hydrologic Subarea	E	E	E	P	E	E	E	E	E	E	E	E	E			E	E		E	E			P				
111.23	Yager Creek Hydrologic Subarea	E	E	E	P	E	E		P	E	E	E	E	E			E	E		E	E			E	E			
111.30	South Fork Eel River Hydrologic Area																											
111.31	Weott Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E	E	E			E	E		E	E			P				
111.32	Benbow Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E	E	E			E	E		E	E			P				
111.33	Laytonville Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E	E	E			E	E		E	E			P				
111.40	Middle Fork Eel River Hydrologic Area																											
111.41	Sequoia Hydrologic Subarea	E	E	E	P	E	E	E	E	E	E	E	E	E			E	E		E	E			P				
111.42	Spy Rock Hydrologic Subarea	E	E	E	P	E	E	E	E	E	E	E	E	E			E	E		E	E			P				
111.50	North Fork Eel River Hydrologic Area	E	E	E	P	E	E	E	E	E	E	E	E	E			E	E		E	E			P				
111.60	Upper Main Eel River Hydrologic Area																											
111.61	Outlet Creek Hydrologic Subarea	E	E	E	P	E		E	P	E	E	E	E	E			E	E		E	E			E				
111.62	Tomki Creek Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E	E	E			E	E		E	E			E				
111.63	Lake Pillsbury Hydrologic Subarea	E	E	E	P	E	E	E	E	E	E	E	E	E			E	E		E	E			E				

TABLE 2-1: BENEFICIAL USES OF WATERS OF THE NORTH COAST REGION

HU/HA/ HSA	HYDROLOGIC UNIT/AREA/ SUBUNIT/DRAINAGE FEATURE	BENEFICIAL USES																										
		MUN	AGR	IND	PRO	GWR	FRSH	NAV	POW	REC1	REC2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL	EST	AQUA	CUL	FLD	WET	WQE
111.70	Middle Fork Eel River Hydrologic Area																											
111.71	Eden Valley Hydrologic Subarea	E	E	E	P		E	E	P	E	E	E	E	E			E	E		E	E			E				
111.72	Round Valley Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E	P	E			E	E		E	E			E				
111.73	Black Butte River Hydrologic Subarea	E	E	E	P		E	E	E	E	E	E	E	E			E	E		E	E			P				
111.74	Wilderness Hydrologic Subarea	E	E	E	P		E	E	E	E	E	E	E	E			E	E		E	E			P				
112.00	**Cape Mendocino Hydrologic Unit**																											
112.10	Oil Creek Hydrologic Area	P	E	E	P		E		P	E	E	E		E			E	E		E	E		E	E	E			
112.20	Capetown Hydrologic Area	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E			P	E			
112.30	Mattole River Hydrologic Area	E	E	E	P	E	E	E	P	E	E	E	P	E			E	E		E	E		E	E				
113.00	**Mendocino Coast Hydrologic Unit**																											
113.10	Rockport Hydrologic Area	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E	P				
113.11	Usal Creek Hydrologic Subarea	E	P	P	P	E	E	E	P	E	E	E		E			E	E		E	E							
113.12	Wages Creek Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E							
113.13	Ten Mile River Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E	P				
113.20	Noyo River Hydrologic Area	E	E	E	P	E	E	E	E	E	E	E		E			E	E		E	E		E	E				
113.30	Big River Hydrologic Area	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E	P				
113.40	Albion River Hydrologic Area	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E	P				
113.50	Navarro River Hydrologic Area	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E	P				
113.60	Pt Arena Hydrologic Area																											
113.61	Greenwood Creek Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E	P				
113.62	Elk Creek Hydrologic Subarea	P	P	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E	P				
113.63	Alder Creek Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E	P				
113.64	Brush Creek Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E		E	P				

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HU/HA/ HSA	HYDROLOGIC UNIT/AREA/ SUBUNIT/DRAINAGE FEATURE	BENEFICIAL USES																										
		MUN	AGR	IND	PRO	GWR	FRSH	NAV	POW	REC1	REC2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL	EST	AQUA	CUL	FLD	WET	WQE
113.70	Garcia River Hydrologic Area	E	E	E	P		E	E	P	E	E	E		E			E	E		E	E		E	P				
113.80	Gualala River Hydrologic Area																											
113.81	North Fork Gualala Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E		E			E	E		E	E			E				
113.82	Rockpile Creek Hydrologic Subarea	E	E	E	P	E		E	P	E	E	E	E	E			E	E		E	E		E	P				
113.83	Buckeye Creek Hydrologic Subarea	E	E	E	P	E		E	P	E	E	E	E	E			E	E		E	E			P				
113.84	Wheatfield Fork Hydrologic Subarea	E	E	E	P	E		E	P	E	E	E	E	E			E	E		E	E			P				
113.85	Gualala Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E	E	E			E	E		E	E			P				
113.90	Russian Gulch Hydrologic Area	E	E	E	P	E				E	E	P		E		E	E			E	E			E				
114.00	**Russian River Hydrologic Unit**																											
114.10	Lower Russian River Hydrologic Area																											
114.11	Guerneville Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E	E	E			E	E		E	E	P	E	P				
114.12	Austin Creek Hydrologic Subarea	E	E	E	P	E		E	P	E	E	E	E	E			E	E		E	E			P				
114.20	Middle Russian River Hydrologic Area																											
114.21	Laguna Hydrologic Subarea	P	E	E	P	E	E	E	E	E	E	E	E	E			E	E		E	E	P		P				
114.22	Santa Rosa Hydrologic Subarea	E	E	E	P	E		E	P	E	E	E	E	E			E	E		E	E	P		P				
114.23	Mark West Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E	E	E			E	E		E	E	P		P				
114.24	Warm Springs Hydrologic Subarea	E	E	E	P	E	E	E	E	E	E	E	E	E			E	E		E	E			E				
114.25	Geyserville Hydrologic Subarea	E	E	E	P	E	E	E	P	E	E	E	E	E			E	E		E	E	P		P				
114.26	Sulphur Creek Hydrologic Subarea	E	E	E	P	E		E	P	E	E	E	E	E			E	E		E	E			P				

TABLE 2-1: BENEFICIAL USES OF WATERS OF THE NORTH COAST REGION

HU/HA/ HSA	HYDROLOGIC UNIT/AREA/ SUBUNIT/DRAINAGE FEATURE	BENEFICIAL USES																										
		MUN	AGR	IND	PRO	GWR	FRSH	NAV	POW	REC1	REC2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL	EST	AQUA	CUL	FLD	WET	WQE
114.30	Upper Russian River Hydrologic Area																											
114.31	Ukiah Hydrologic Subarea	E	E	E	P	E	E	E	E	E	E	E	E	E			E	E		E	E	P		P				
114.32	Coyote Valley Hydrologic Subarea	E	E	E	P	E	E	E	E	E	E	E	E	E			E	E		E	E			P				
114.33	Forsythe Creek Hydrologic Subarea	E	E	E	P	E		E	P	E	E	E	E	E			E	E		E	E			P				
115.00	**Bodega Hydrologic Unit**																											
115.10	Salmon Creek Hydrologic Area	E	E	E	P	E		E		E	E	E		E			E	E		E	E	P	E	P				
115.20	Bodega Harbor (or Bay) Hydrologic Area	E	E	E	P	E		E		E	E	E		E			E	E	E	E	E	E		E				
115.30	Estero Americano Hydrologic Area	E	E	E	P	E		E		E	E	E		E			E	E	E	E	E	P	E	P				
115.40	Estero de San Antonio Hydrologic Area	E	E	E	P	E		E		E	E	E		E			E	E	E	E	E	P	E	P				
	Minor Coastal Streams (not listed above**)	E	P	P	P	P	P	P		P	P	E	P	P			E	E	P	P	P		E	P	P			
	Ocean Waters			P	P			E		E	E	E			P		E	E	E	E	E	E		E				
	Bays			P	P			E		P	E	E	P	E			E	P	E	E	E	E	P	P	P			
	Saline Wetlands			P		P	P	P		P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P	E	P
	Freshwater Wetlands	P	P	P		P	P	P		P	P	P	P	P			P	P		P	P	P	P	P	P	P	E	P
	Estuaries	P	P	P	P		P	E	P	E	E	P	P	E			E	P	E	E	E	E	E	P	P			
	Groundwater	E	E	E	P																			P	E			

Waterbodies are grouped by hydrologic unit (HU) or hydrologic area (HA).
*EST use applies only to the estuarine portion of the waterbody as defined in Chapter 2. **Permanent and intermittent P = Potential E = Existing

pH

The pH shall conform to those limits listed in Table 3-1. For waters not listed in Table 3-1 and where pH objectives are not prescribed, the pH shall not be depressed below 6.5 nor raised above 8.5. Changes in normal ambient pH levels shall not exceed 0.2 units in waters with designated marine (MAR) or saline (SAL) beneficial uses nor 0.5 units within the range specified above in fresh waters with designated COLD or WARM beneficial uses.

Dissolved Oxygen

Dissolved oxygen concentrations shall conform to those limits listed in Table 3-1. For waters not listed in Table 3-1 and where dissolved oxygen objectives are not prescribed the dissolved oxygen concentrations shall not be reduced below the following minimum levels at any time.

Waters designated WARM, MAR, or SAL ..... 5.0 mg/l
Waters designated COLD .... 6.0 mg/l
Waters designated SPWN.............................. 7.0 mg/l
Waters designated SPWN during critical spawning and egg incubation periods .... 9.0 mg/l

Bacteria

The bacteriological quality of waters of the North Coast Region shall not be degraded beyond natural background levels. In no case shall coliform concentrations in waters of the North Coast Region exceed the following:

In waters designated for contact recreation (REC-1), the median fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed 50/100 ml, nor shall more than ten percent of total samples during any 30-day period exceed 400/100 ml (State Department of Health Services).

At all areas where shellfish may be harvested for human consumption (SHELL), the fecal coliform concentration throughout the water column shall not exceed 43/100 ml for a 5-tube decimal dilution test or 49/100 ml when a three-tube decimal dilution test is used (National Shellfish Sanitation Program, Manual of Operation).

Temperature

Temperature objectives for COLD interstate waters, WARM interstate waters, and Enclosed Bays and Estuaries are as specified in the "Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays of California" including any revisions thereto. A copy of this plan is included verbatim in the Appendix Section of this Plan. In addition, the following temperature objectives apply to surface waters:

The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alteration in temperature does not adversely affect beneficial uses.

At no time or place shall the temperature of any COLD water be increased by more than 5°F above natural receiving water temperature.

At no time or place shall the temperature of WARM intrastate waters be increased more than 5°F above natural receiving water temperature.

Toxicity

All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration, or other appropriate methods as specified by the Regional Water Board.

The survival of aquatic life in surface waters subjected to a waste discharge, or other controllable water quality factors, shall not be less than that for the same water body in areas unaffected by the waste discharge, or when necessary for other control water that is consistent with the requirements for "experimental water" as described in "**Standard Methods for the Examination of Water and Wastewater"**, 18th Edition (1992). As a minimum, compliance with this objective as stated in the previous sentence shall be evaluated with a 96-hour bioassay.

In addition, effluent limits based upon acute bioassays of effluents will be prescribed. Where appropriate, additional numerical receiving water objectives for specific toxicants will be established as sufficient data become available, and source control of toxic substances will be encouraged.

TABLE 3-1

SPECIFIC WATER QUALITY OBJECTIVES FOR NORTH COAST REGION

	Specific Conductance (micromhos) @ 77°F		Total Dissolved Solids (mg/l)		Dissolved Oxygen (mg/l)			Hydrogen Ion (pH)		Hardness (mg/l)	Boron (mg/l)	
Waterbody[1]	90% Upper Limit[3]	50% Upper Limit[2]	90% Upper Limit[3]	50% Upper Limit[2]	Min	90% Lower Limit[3]	50% Lower Limit[2]	Max	Min	50% Upper Limit[2]	90% Upper Limit[3]	50% Upper Limit[2]
Lost River HA												
Clear Lake Reservoir & Upper Lost River	300	200			5.0		8.0	9.0	7.0	60	0.5	0.1
Lower Lost River	1000	700			5.0		-	9.0	7.0	-	0.5	0.1
Other Streams	250	150			7.0		8.0	8.4	7.0	50	0.2	0.1
Tule Lake	1300	900			5.0		-	9.0	7.0	400	-	-
Lower Klamath Lake	1150	850			5.0		-	9.0	7.0	400	-	-
Groundwaters [4]	1100	500			-		-	8.5	7.0	250	0.3	0.2
Butte Valley HA												
Streams	150	100			7.0		9.0	8.5	7.0	30	0.1	0.0
Meiss Lake	2000	1300			7.0		8.0	9.0	7.5	100	0.3	0.1
Groundwaters [4]	800	400			-		-	8.5	6.5	120	0.2	0.1
Shasta Valley HA												
Shasta River	800	600			7.0		9.0	8.5	7.0	220	1.0	0.5
Other Streams	700	400			7.0		9.0	8.5	7.0	200	0.5	0.1
Lake Shastina	300	250			6.0		9.0	8.5	7.0	120	0.4	0.2
Groundwaters [4]	800	500			-		-	8.5	7.0	180	1.0	0.3
Scott River HA												
Scott River	350	250			7.0		9.0	8.5	7.0	100	0.4	0.1
Other Streams	400	275			7.0		9.0	8.5	7.0	120	0.2	0.1
Groundwaters [4]	500	250			-		-	8.0	7.0	120	0.1	0.1
Salmon River HA												
All Streams	150	125			9.0		10.0	8.5	7.0	60	0.1	0.0
Middle Klamath River HA												
Klamath River above Iron Gate Dam including Iron Gate & Copco Reservoirs	425	275			7.0		10.0	8.5	7.0	60	0.3	0.2
Klamath River below Iron Gate Dam	350	275			8.0		10.0	8.5	7.0	80	0.5	0.2
Other Streams	300	150			7.0		9.0	8.5	7.0	60	0.1	0.0
Groundwaters [4]	750	600			-		-	8.5	7.5	200	0.3	0.1
Applegate River HA												
All Streams	250	175			7.0		9.0	8.5	7.0	60	-	-
Upper Trinity River HA												
Trinity River [5]	200	175			7.0		10.0	8.5	7.0	80	0.1	0.0
Other Streams	200	150			7.0		10.0	8.5	7.0	60	0.0	0.0
Clair Engle Lake and Lewiston Reservoir	200	150			7.0		10.0	8.5	7.0	60	0.0	0.0

TABLE 3-1 (CONTINUED)

SPECIFIC WATER QUALITY OBJECTIVES FOR NORTH COAST REGION

	Specific Conductance (micromhos) @ 77°F		Total Dissolved Solids (mg/l)		Dissolved Oxygen (mg/l)			Hydrogen Ion (pH)		Hardness (mg/l)	Boron (mg/l)	
Waterbody[1]	**90% Upper Limit[3]**	**50% Upper Limit[2]**	**90% Upper Limit[3]**	**50% Upper Limit[2]**	**Min**	**90% Lower Limit[3]**	**50% Lower Limit[2]**	**Max**	**Min**	**50% Upper Limit[2]**	**90% Upper Limit[3]**	**50% Upper Limit[2]**
Hayfork Creek												
Hayfork Creek	400	275			7.0		9.0	8.5	7.0	150	0.2	0.1
Other Streams	300	250			7.0		9.0	8.5	7.0	125	0.0	0.0
Ewing Reservoir	250	200			7.0		9.0	8.0	6.5	150	0.1	0.0
Groundwaters [4]	350	225			-		-	8.5	7.0	100	0.2	0.1
S.F. Trinity River HA												
S.F. Trinity River	275	200			7.0		10.0	8.5	7.0	100	0.2	0.0
Other Streams	250	175			7.0		9.0	8.5	7.0	100	0.0	0.0
Lower Trinity River HA												
Trinity River	275	200			8.0		10.0	8.5	7.0	100	0.2	0.0
Other Streams	250	200			9.0		10.0	8.5	7.0	100	0.1	0.0
Groundwaters [4]	200	150			-		-	8.5	7.0	75	0.1	0.1
Lower Klamath River HA												
Klamath River	300[6]	200[6]			8.0		10.0	8.5	7.0	75[6]	0.5[6]	0.2[6]
Other Streams	200[6]	125[6]			8.0		10.0	8.5	6.5	25[6]	0.1[6]	0.0[6]
Groundwaters [4]	300	225			-		-	8.5	6.5	100	0.1	0.0
Illinois River HA												
All Streams	200	125			8.0		10.0	8.5	7.0	75	0.1	0.0
Winchuck River HU												
All Streams	200[6]	125[6]			8.0		10.0	8.5	7.0	50[6]	0.0[6]	0.0[6]
Smith River HU												
Smith River-Main Forks	200	125			8.0		11.0	8.5	7.0	60	0.1	0.1
Other Streams	150[6]	125[6]			7.0		10.0	8.5	7.0	60[6]	0.1[6]	0.0[6]
Smith River Plain HSA												
Smith River	200[6]	150[6]			8.0		11.0	8.5	7.0	60[6]	0.1[6]	0.0[6]
Other Streams	150[6]	125[6]			7.0		10.0	8.5	6.5	60[6]	0.1[6]	0.0[6]
Lakes Earl & Talawa	-	-			7.0		9.0	8.5	6.5	-	-	-
Groundwaters [4]	350	100			-		-	8.5	6.5	75	1.0	0.0
Crescent City Harbor	-	-										
Redwood Creek HU												
Redwood Creek	220[6]	125[6]	115[6]	75[6]	7.0	7.5	10.0	8.5	6.5			
Mad River HU												
Mad River	300[6]	150[6]	160[6]	90[6]	7.0	7.5	10.0	8.5	6.5			
Eureka Plain HU												
Humboldt Bay	-	-	-	-	6.0	6.2	7.0	8.5	7			
Eel River HU												
Eel River	375[6]	225[6]	275[6]	140[6]	7.0	7.5	10.0	8.5	6.5			
Van Duzen River	375	175	200	100	7.0	7.5	10.0	8.5	6.5			

TABLE 3-1 (CONTINUED)

SPECIFIC WATER QUALITY OBJECTIVES FOR NORTH COAST REGION

	Specific Conductance (micromhos) @ 77°F		Total Dissolved Solids (mg/l)		Dissolved Oxygen (mg/l)			Hydrogen Ion (pH)		Hardness (mg/l)	Boron (mg/l)	
Waterbody[1]	90% Upper Limit[3]	50% Upper Limit[2]	90% Upper Limit[3]	50% Upper Limit[2]	Min	90% Lower Limit[3]	50% Lower Limit[2]	Max	Min	50% Upper Limit[2]	90% Upper Limit[3]	50% Upper Limit[2]
South Fork Eel River	350	200	200	120	7.0	7.5	0.0	8.5	6.5			
Middle Fork Eel River	450	200	230	130	7.0	7.5	10.0	8.5	6.5			
Outlet Creek	400	200	230	125	7.0	7.5	10.0	8.5	6.5			
Cape Mendocino HU												
Bear River	390[6]	255[6]	240[6]	150[6]	7.0	7.5	10.0	8.5	6.5			
Mattole River	300[6]	170[6]	170[6]	105[6]	7.0	7.5	10.0	8.5	6.5			
Mendocino Coast HU												
Ten Mile River	-	-	-	-	7.0	7.5	10.0	8.5	6.5			
Noyo River	185[6]	150[6]	120[6]	105[6]	7.0	7.5	10.0	8.5	6.5			
Jug Handle Creek	-	-	-	-	7.0	7.5	10.0	8.5	6.5			
Big River	300[6]	195[6]	190[6]	130[6]	7.0	7.5	10.0	8.5	6.5			
Albion River	-	-	-	-	7.0	7.5	10.0	8.5	6.5			
Navarro River	285[6]	250[6]	170[6]	150[6]	7.0	7.5	10.0	8.5	6.5			
Garcia River	-	-	-	-	7.0	7.5	10.0	8.5	6.5			
Gualala River	-	-	-	-	7.0	7.5	10.0	8.5	6.5			
Russian River HU												
(upstream) [8]	320	250	170	150	7.0	7.5	10.0	8.5	6.5			
(downstream) [9]	375[6]	285[6]	200[6]	170[6]	7.0	7.5	10.0	8.5	6.5			
Laguna de Santa Rosa	-	-	-	-	7.0	7.5	10.0	8.5	6.5			
Bodega Bay	-	-	-	-	6.0	6.2	7.0	8.5	7			
Coastal Waters [10]	-	-	-	-	11	11	11	12	12			

1 Water bodies are grouped by hydrologic unit (HU), hydrologic area (HA), or hydrologic subarea (HSA).

2 50% upper and lower limits represent the 50 percentile values of the monthly means for a calendar year. 50% or more of the monthly means must be less than or equal to an upper limit and greater than or equal to a lower limit.

3 90% upper and lower limits represent the 90 percentile values for a calendar year. 90% or more of the values must be less than or equal to an upper limit and greater than or equal to a lower limit.

4 Value may vary depending on the aquifer being sampled. This value is the result of sampling over time, and as pumped, from more than one aquifer.

5

Daily Average Not to Exceed	Period	River Reach
60°F	July 1 - Sept. 14	Lewiston Dam to Douglas City Bridge
56°F	Sept. 15 - Oct. 1	Lewiston Dam to Douglas City Bridge
56°F	Oct. 1 - Dec. 31	Lewiston Dam to confluence of North Fork Trinity River

6 Does not apply to estuarine areas.

7 pH shall not be depressed below natural background levels.

8 Russian River (upstream) refers to the mainstem river upstream of its confluence with Laguna de Santa Rosa.

9 Russian River (downstream) refers to the mainstem river downstream of its confluence with Laguna de Santa Rosa.

10 The State's Ocean Plan applies to all North Coast Region coastal waters.

11 Dissolved oxygen concentrations shall not at any time be depressed more than 10 percent from that which occurs naturally.

12 pH shall not be changed at any time more than 0.2 units from that which occurs naturally.

\- no water body specific objective available.

Table 2. Dissolved Oxygen Concentrations (mg/L) Versus Quantitative Level of Effect.

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1. Salmonid Waters

   a. Embryo and Larval Stages

No Production Impairment	=	11* (8)
Slight Production Impairment	=	9* (6)
Moderate Production Impairment	=	8* (5)
Severe Production Impairment	=	7* (4)
Limit to Avoid Acute Mortality	=	6* (3)

(* Note: These are water column concentrations recommended to achieve the required intergravel dissolved oxygen concentrations shown in parentheses. The 3 mg/L difference is discussed in the criteria document.)

   b. Other Life Stages

No Production Impairment	=	8
light Production Impairment	=	6
Moderate Production Impairment	=	5
Severe Production Impairment	=	4
Limit to Avoid Acute Mortality	=	3

2. Nonsalmonid Waters

   a. Early Life Stages

No Production Impairment	=	6.5
Slight Production Impairment	=	5.5
Moderate Production Impairment	=	5
Severe Production Impairment	=	4.5
Limit to Avoid Acute Mortality	=	4

   b. Other Life Stages

No Production Impairment	=	6
Slight Production Impairment	=	5
Moderate Production Impairment	=	4
Severe Production Impairment	=	3.5
Limit to Avoid Acute Mortality	=	3

3. Invertebrates

No Production Impairment	=	8
Some Production Impairment	=	5
Acute Mortality Limit	=	4